GEOLOGICAL SURVEY OF GEORGIA

W. S. YEATES, State Geologist

BULLETIN No. 2

A

Preliminary Report

on the

Corundum

DEPOSITS

OF

GEORGIA

BY

FRANCIS P. KING

Assistant Geologist

1894

GEO. W. HARRISON, State Printer

Atlanta, Ga.

With the compliments of

W. S. Yeates,

State Geologist.

PLATE I. FRONTISPIECE.

LAUREL CREEK CORUNDUM MINES, RABUN COUNTY, GEORGIA.

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ATLANTA, GA.
THE FRANKLIN PRINTING AND PUBLISHING CO.
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STATE OF GEORGIA, GEOLOGICAL SURVEY,
ATLANTA, Sept. 15, 1894.

To His Excellency, W. J. Northen, Governor, and President of the Advisory Board of the Geological Survey of Georgia,

SIR:—I have the honor to transmit, herewith, the report of Mr. Francis P. King, Assistant Geologist, on the Corundum Deposits of Georgia.

The importance of corundum in the arts, and the high price it commands, should make this report of special interest, Georgia ranking second in the Union, in its production. It is hoped, that this publication will act as a stimulus to the discovery, in Georgia, of other deposits of this valuable mineral.

Like the report on the "Marbles of Georgia," this bulletin is preliminary to a final general report, in which it will be incorporated, with such additional information, as we may be able to get, bringing the subject up to date.

Very respectfully yours,
W. S. YEATES,
State Geologist.

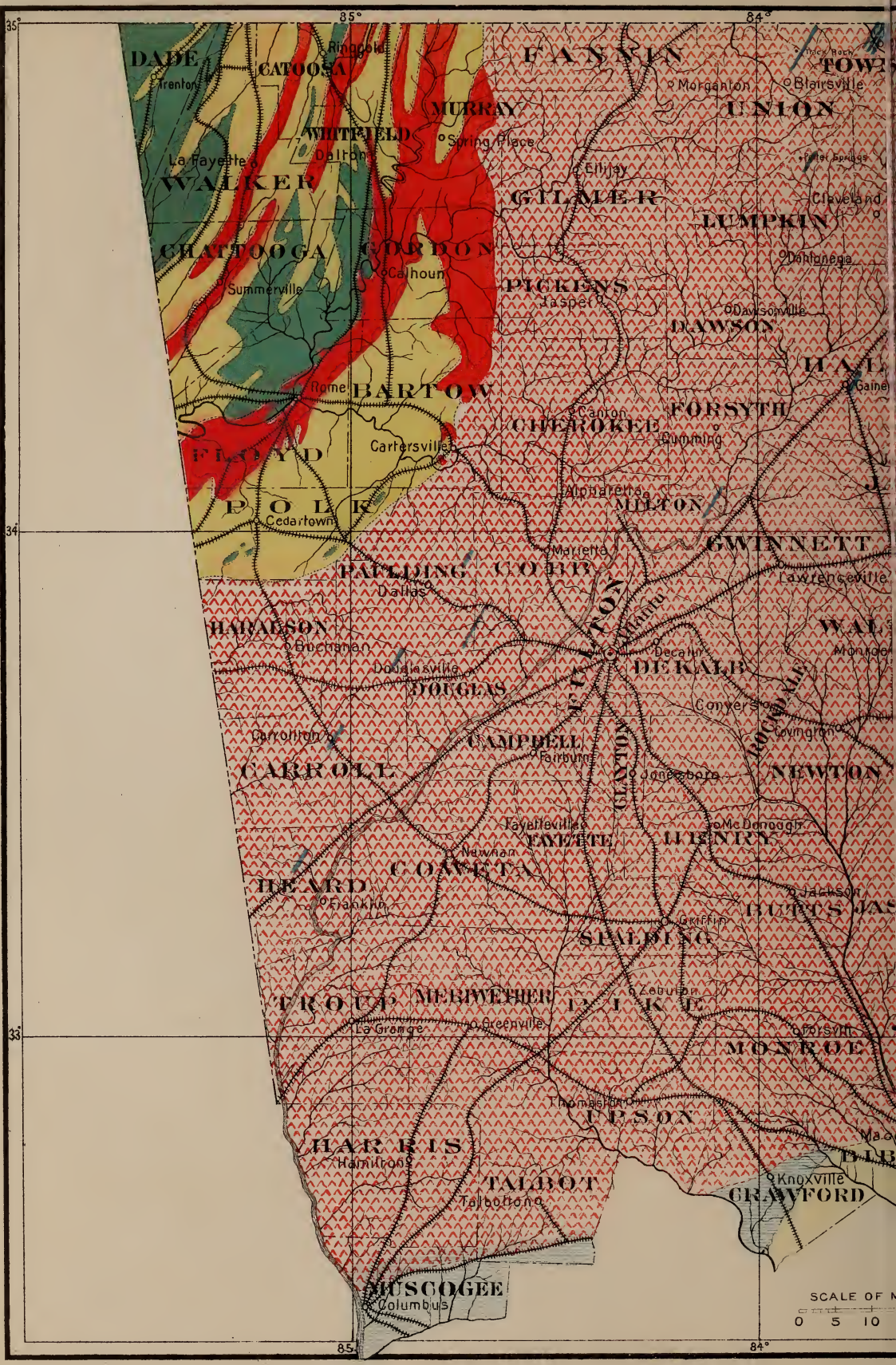
PREFACE.

The subject-matter of this report, it is hoped, is of a nature, to fill a want, continually expressed to the Survey, by citizens interested in this special line of work. In its presentation, with this expression of need in mind, technicalities have been avoided, in so far as scientific treatment would permit, and many features have been elaborated; in other words, an attempt has been made to harmonize scientific accuracy and practical usefulness, by introducing such material, and presenting all, in such a manner, that the report will be both serviceable and easily intelligible to the average reader.

Several of the chemical analyses, which appear in this volume, were made in the laboratory of the Survey by Dr. William H. Emerson, Professor of Chemistry in the Georgia School of Technology. His careful and admirable work speaks for itself.

In conclusion, I desire to express my obligations to the State Geologist for many favors; also, to many citizens of the State for their assistance and hospitality. Space will not permit the enumeration of all these; but I would mention in particular, Mr. Thomas S. Bean of Clarkesville, Mrs. H. A. Burdick, Manager of the Laurel Creek Corundum Mine, Pine Mountain, Rabun Co., Ga., Mr. Corn of Visage, Mr. William R. McConnell and Mr. O. C. Wyly of Hiawassee, Mr. John McConnell of Gainesville, Mr. R. J. Cook of Track Rock, Prof. Leon P. Smith of La Grange, and Dr. E. D. Little of Sheltonville.

Sept. 15, 1894. F. P. K.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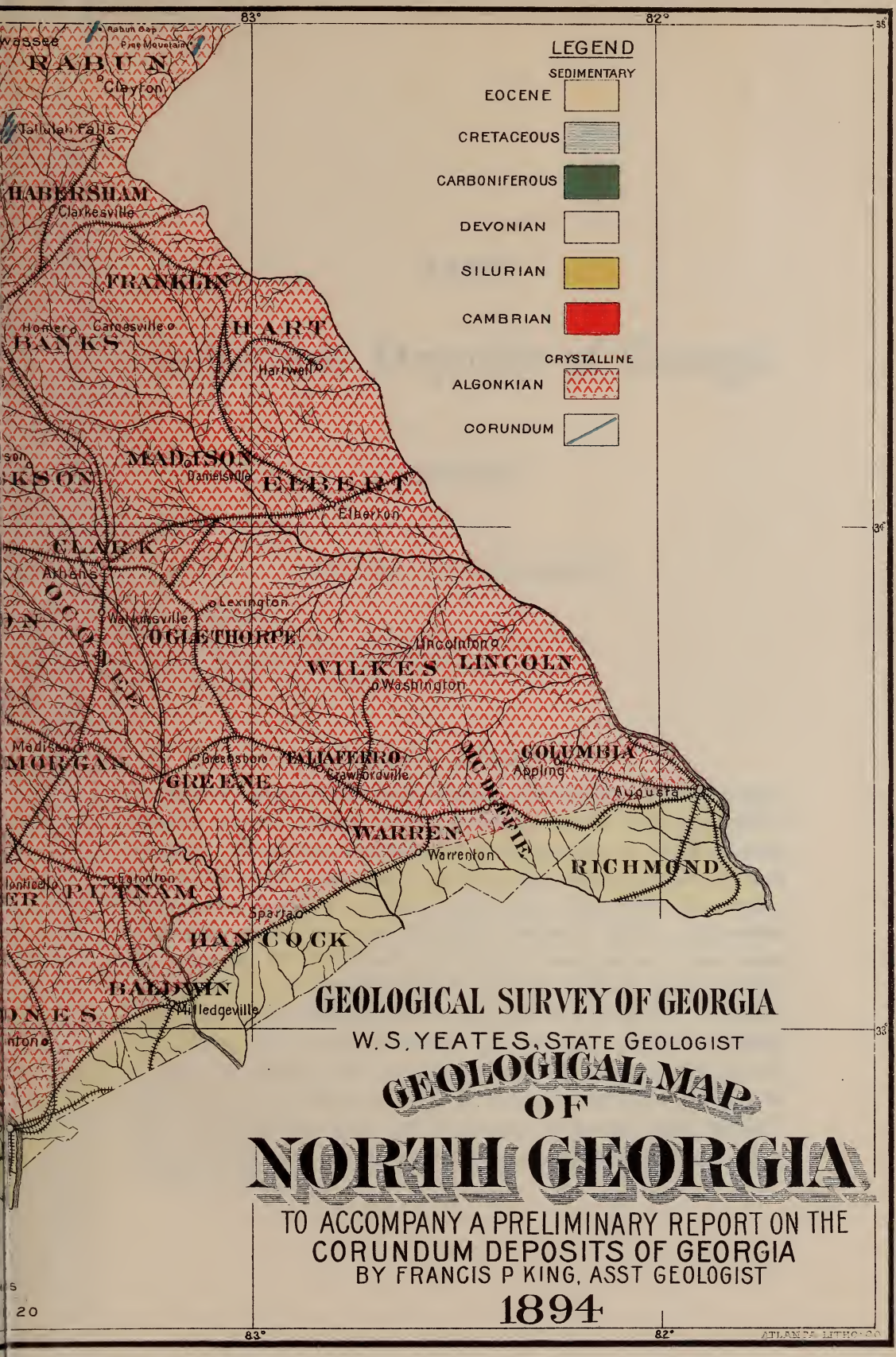
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GEOLOGICAL SURVEY OF GEORGIA
W. S. YEATES, STATE GEOLOGIST
GEOLOGICAL MAP
OF
NORTH GEORGIA
TO ACCOMPANY A PRELIMINARY REPORT ON THE
CORUNDUM DEPOSITS OF GEORGIA
BY FRANCIS P KING, ASST GEOLOGIST
1894

THE

Corundum Deposits of Georgia

CHAPTER I.

HISTORY OF CORUNDUM.

EARLY HISTORY.

Little is known of the early history of corundum, although speculations are rife among writers, dwelling on the handiwork of the ancients. Thus, the dexterity of the Egyptians in stone-carving, several thousand years before the Christian era, as shown by their monuments, suggests to these writers, that the work was accomplished by means of some very hard abrasive, such as corundum. For example, Mr. Wilkinson, the English antiquarian, whose scientific researches in Egyptian history are well known, writes:—"It is in no wise improbable, that they were familiar with the use of emery, at the time, when that substance, which is met with in the islands of the Archipelago, was accessible to them; and, if this be admitted, we can explain the perfection and admirable delicacy of their hieroglyphics upon the monuments of granite and basalt."[1]

[1] Manners and Customs of the Ancient Egyptians, by Wilkinson. 1st Edition, Vol. III., pp. 250–257.

More authentic knowledge of the ancients' acquaintance with corundum is confined to the gems of corundum. That they appreciated their value, and sought them as eagerly as we, may be fully understood, when we learn that they regarded the ruby as the very type of all, that is most precious in the natural world. Moreover, we know that the desire to possess, led men to seek them in foreign lands in the time of Solomon. In the Bible, we find the gems of corundum mentioned quite frequently. In Exodus, chapter xxviii, we learn that the breastplate, which God commanded the people to make for Aaron, was to contain, among the twelve precious stones, a carbuncle [2] and a sapphire. Ezekiel tells us, that the king of Tyre had as a covering, among other precious stones, both the ruby and the sapphire. John, in Revelations, describes the foundations of the walls of the heavenly city, as being "garnished with all manner of precious stones," among which were the gems of corundum.

The early Greek writers teem with descriptions and allusions to these gems. From these, we learn that they engraved and cut them, long before the Christian era, and that, in Egypt, they were worked as Scariabean gems. From such writers, also, we learn that the ancients believed the occurrence of precious stones to be confined to certain climates, and "were wont to ascribe the preëminence of certain regions to evaporation from the earth, in which precious stones are found, an evaporation obviously more intense in tropical countries. It was a supposition, pardonably fanciful, that the sun-burnt tropics were more favorable to the blossoms of the organic world, than the dark skies of the north."[3] Naturally, to stones so rare and possessed of such wonderful beauty, the ancients attached miraculous power, increasing inestimably their preciousness. It is unnecessary, perhaps, to say that these ancient superstitions have not been entirely effaced; and to-day people may be found, who still give credence to these ancient beliefs. This superstition, particularly, makes the ancient writers' mention of them so fanciful and obscure, that we are often left in doubt, as to real name of the stones.

[2] There is little doubt among authorities, but that the Greek word *anthrax*, here translated carbuncle, is the corundum gem, ruby.

[3] Edwin W. Streeter; Precious Stones and Gems; 3rd Edition, p. 7.

We find, nevertheless, certain writings of the Greeks, as far back as the sixth century B. C., which indicate a considerable knowledge of the physical properties of these gems. In the fifth century B. C., the writings of the Greeks begin to show special acumen in the description of minerals, as seen in the writings of Aristotle and his pupil, Theophrastus, the latter writing an excellent treatise on mineralogy.

Roman succession to the treasure-field marked an increase in mineralogical knowledge and a fuller acquaintance with the characteristics of these gems. Pliny, especially, seems to be well informed, as to where the precious ruby and sapphire occur, and his descriptions of them are sharp and observant. Passing into the Christian era, writers on mineralogy increase, and the subject is developed into a science; but the superstitious legend of the past continued more or less gospel, and precious stones were still worshipped, worn as amulets etc. The twelve apostles were represented by gems called Apostle Stones; and thus the beautiful blue sapphire became emblematic of the heavenly faith of Andrew.

HISTORY OF CORUNDUM IN THE EASTERN HEMISPHERE.

The first known occurrence of corundum is the emery of the Grecian Islands. It is supposed that the early Egyptians obtained emery from this point, and made considerable use of it in the arts. Indeed, up to the time of the discovery of emery in Asia Minor, in 1847, by Dr. J. Lawrence Smith, of Louisville, Ky., it was exported exclusively from these islands, principally from the Island of Naxos in the Grecian Archipelago. The owners of these mines completely controlled the price of emery, and were selling their product at from forty to fifty dollars per ton. At the time Dr. Smith, in the employ of the Turkish Government, made his important discovery, these mines had been purchased from the Greek Government, by an English merchant, and the price had advanced to one hundred and forty dollars per ton. This new discovery reduced the price, writes Dr. Smith in 1850, to fifty and seventy dollars a ton according to quality. The importance of this discovery was not appropriated completely by the Turkish Government. Corundum,

formerly of little interest, except in the arts and as a gem, took on a new importance under the able researches of Dr. Smith. Previous to this time, it was known to occur, only in a few localities, while, as to the method of its occurrence, that is, its geological relation, very little was known. In 1850, Dr. Smith presented two papers before the Academy of Science of Paris—to quote his own words[1]—"in which the subject was thoroughly discussed, and, I might say, almost exhausted." If Dr. Smith did not *exhaust* the subject, he at least developed such important facts, in regard to its geological relations and associate minerals, as to urge investigation and the consequent discovery of many new localities, both in the Old and the New World.

The occurrence of corundum in the Eastern Hemisphere according to Dana is as follows:—"The best rubies come from the mines in Upper Burma, north of Mandalay, in an area covering 25 to 29 square miles, of which Magok is the center. Also found in the marble hills of Sagyin, 16 miles north of Mandalay. The rubies occur *in situ* in crystalline limestone; also in the soil of the hillsides, and in gem-bearing gravel. All the crystallized varieties of the species occur here; the spinel-ruby is an associate. A ruby weighing 304 carats is said to have been found here in 1890. Rubies and sapphires have also been reported from other localities, and the massive varieties are common, especially in the crystalline rocks of southern India. Ruby mines have also been worked at Jagdalak, 32 miles east of Kábul, Afghanistan. Some fine sapphires were obtained in 1882 from the Zánskár range of the Kashmir Himalayas, near the village Machel in Padar; and, since then, mining has been carried on there, with some success. Blue sapphires are brought from Ceylon, often as rolled pebbles, but also, as well preserved crystals. Corundum occurs in the Carnatic, on the Malabar coast, on the Chantibun hills in Siam, and elsewhere in the East Indies; also near Canton, China. At St. Gothard, it occurs of a red or blue tinge in dolomite, and near Mozzo in Piedmont, in white compact feldspar. Adamantine spar is met with, in large, coarse, hexagonal pyramids in Gellivara, Sweden.

[1] Dr. J. Lawrence Smith; Emery Mine of Chester; Scientific Researches, p. 42.

Emery is found in large bowlders at Naxos, Nicaria and Samos of the Grecian islands; also in Asia Minor, 12 miles east of Ephesus, near Gumuch-dagh, where it was discovered *in situ* by Dr. J. Lawrence Smith, associated with margarite, chloritoid, pyrite, calcite etc.; and, also, at Kulah, Adulah and Manser, the last, 24 miles north of Smyrna; also, with the nacrite (?) of Cumberland, England. Other localities are in Bohemia, near Petscha, in the Ural, near Ekaterinburg, and in the Ilmen mountains, not far from Miask; in the gold-washings northeast of Zlatoust, as small crystals (called *soimonite* after Senator Soimonov) in barsovite. Corundum, sapphires and, less often, rubies occur in rolled pebbles, in the diamond gravels on the Cudgegong river, at Mudgee and other points in New South Wales."[1]

HISTORY OF CORUNDUM IN NORTH AMERICA.

GENERAL REMARKS.

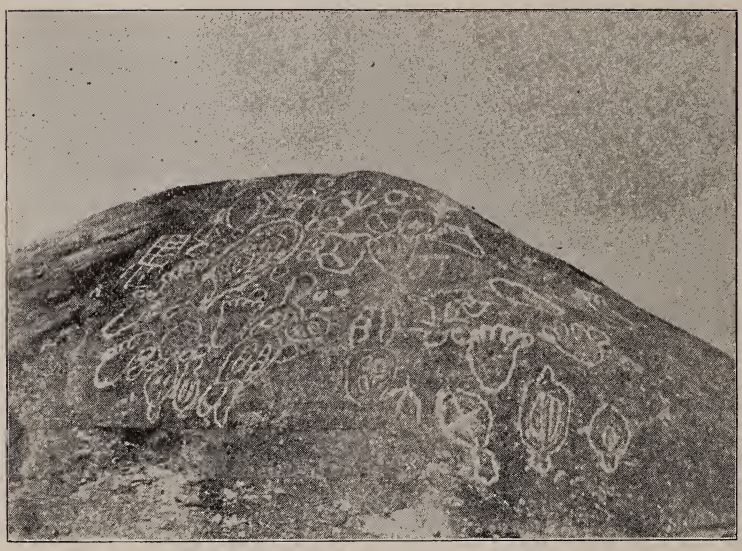
Authentic history of corundum in America dates back to the early part of this century. Whether or not the Indians knew of its presence, and made use of it, is simply a matter of conjecture. Their presence in the neighborhood of the occurrences in Georgia is everywhere apparent. This is evidenced in the old carvings on rocks, and the presence of incomplete or broken utensils. The soapstone of the formation, because of its ease in working, was especially attractive to them for the making of pipes, vessels etc. In the road a few hundred yards above the works at Track Rock Mine, Union county, Ga., there are several slabs, one of which is remarkably well preserved, bearing most curious hieroglyphics deeply cut into the rock. Some of these can be made out, as tracks of animals, while the others only the imaginative are permitted to interpret.[2]

There can be but little doubt, however, that, during their presence in these localities, the glistening beauty of the blue and red fragments of corundum, scattered through the soil, attracted the watchful eye of the red man, and was soon lovingly adapted to savage finery.

[1] Dana; System of Mineralogy—6th Edition; p. p. 212-213.

[2] See figure 1.

FIG I.



TRACK ROCK, UNION COUNTY, GEORGIA.

The first authentic date to be found, of the discovery of corundum in North America is 1845; it was then discovered in the township of Newlin, Chester county, Pa. Following the discovery of emery at Chester, Mass., however, in 1864, and the knowledge of the subject, disseminated by Dr. J. Lawrence Smith, Professor C. U. Shepard and Professor C. T. Jackson, explorers began traversing the eastern crystalline belt of the United States from Virginia to Alabama. The result of their work confirmed the prophesies of the mineralogists; corundum was found all along the line. Mines were opened up in several States, explorers entered the field, and new localities have been continually added to the list, up to the time of the present writing.

Prominent among the early explorers may be mentioned Rev. C. D. Smith and Colonel C. W. Jencks, of North Carolina, and Dr. H. S. Lucas, of Massachusetts. To these indefatigable workers is undoubtedly due the most credit, for the development of the corundum resources of North Carolina and Georgia.

CANADA.—Little is known of the presence of Corundum in Canada. I am informed by Dr. Adams, of McGill College, Montreal, that it is known to occur only in one locality. The record of this, in the survey report for 1863, is as follows:—"Corundum has been observed in the second lot of the 9th range of Burgess,[1] and in the immediate vicinity of a deposit of copper pyrites. Here, in contact with the crystalline limestone, occurs a rock made up of feldspar, quartz, calcite, silvery-white mica and sphene. Disseminated throughout this aggregate were small grains of a mineral, whose color varies from light rose-red to sapphire-blue, while its hardness, which was greater than that of topaz, showed the mineral to be corundum. Small crystals of light-blue corundum have been found elsewhere in the limestone of the vicinity."[2]

MAINE.—Dana says, that a few crystals of corundum have been found at Greenwood in a mica-schist, with beryl, zircon and lepidolite. With this exception, no record of its occurrence in the State can be found. Dr. W. S. Bayley, Professor of Mineralogy and Geology at Colby University, writes that the locality mentioned by Dana is unknown to the collectors.

MASSACHUSETTS.—Professor C. T. Jackson, on October 22nd, 1863, while surveying an iron mine at Chester, Mass., discovered some veins of margarite, and, from this, "ventured to predict the occurrence of emery."[3] About a year later, he met Dr. Lucas, one of the owners of the mine, and again called his attention to this discovery. "The next day after his return to Chester, he (Dr. Lucas) found the emery, a big vein nearly six feet wide, which had been mistaken by him for iron ore, it being very magnetic."[3] This discovery marks the opening of the industry in America. Mills were erected at Chester, Mass., for the preparation of this mineral for the market; but the emery, mined sometime, was finally found to be too soft for the trade, and has since been abandoned. Later, corundum was mined there.

Professor Shepard found the vein to have an extent of about

[1] A township and a province of Ontario.

[2] Report of Geological Survey of Canada for 1863, page 499.

[3] Scientific Researches; J. Lawrence Smith, page 44.

four miles, and an average width of four feet. It extends through a great gneiss formation, flanked on the east by a mica-slate. Between the mica-slate and the eastern gneiss wall, talcose-slates intrude, averaging from twenty to one hundred feet in thickness. No corundum, emery or magnetic particles have thus far been detected as constituents of the gneiss; but particles of these minerals are scattered throughout the talcose formation. The minerals, associated with the emery vein, are corundum, diaspore, ripidolite, margarite etc.

CONNECTICUT.—Professor George J. Brush has in his collection two specimens of corundum, which were found in this State in 1870. This is approximately the date of the discovery of corundum in Connecticut. Dana reports it from near Litchfield, and at Norwich, with sillimanite, rare. It also occurs at Newton, in Fairfield county.

Professor S. L. Penfield writes me, that the crystals are light pink, presenting the simple combination of short hexagonal prisms of the second order with the basal plane. No work has been done to open up a vein ; consequently, the nature of its occurrence is unknown. Professor Penfield thinks it occurs in the crystalline schists, since the crystals of corundum are found embedded in blue kyanite.

NEW YORK.—Corundum was discovered, very early, in this State. It has been found at Warwick and Amity, Orange county, also in Cortlandt Township, Westchester county. The latter locality was described by Professor George H. Williams, in his interesting papers on the "Cortlandt Series." Westchester county, up to last year, when the mining company assigned, was one of the sources of supply to the United States.

NEW JERSEY.—The State Geologist reports, that it was probably first found at Vernon, date unknown. A prolongation of the New York dolomitic limestone, bearing corundum, at Franklin, Newton and Vernon, furnish isolated pockets of blue and red corundum. In Sussex county, it occurs in the gneissoid rock. No economic work on corundum has been done in this State.

MARYLAND.—Tyson reports the occurrence of corundum near White Hall. Considerable work had been done here on magnetic iron and copper ore, in the magnesian belt, previous to the civil war; and, since then, several geologists have examined the locality for corundum, but without success.

PENNSYLVANIA.—In 1845 some large masses of corundum were found on the surface; and later it was mined in Newlin township, Chester county. This is probably the first discovery of corundum in Pennsylvania. A paper on the minerals in the vicinity of Philadelphia, by Dr. Isaac Lea, in the proceedings of the Academy of Natural Sciences, 1818, does not mention corundum, although the writer had explored, to a great extent, Chester and Delaware counties. Following the discovery of corundum in 1845 at Newlin, it was found commencing near Blue Hill, in Upper Providence Township, and extending for about five miles to near Rockdale, Middletown Township, Delaware county, and again appearing near Unionville, in Newlin Township, Chester county. Mr. T. D. Rand, of Philadelphia, who has kindly supplied me with information on the history of corundum in Pennsylvania, says that a locality in Lehigh county shows no indication of serpentine, as at the other localities, but that the corundum occurs chiefly in large, loose crystals in a granitic or syenitic rock. The deposit in Chester county, at the time Dr. Genth wrote Volume B of the Pennsylvania Geological Survey reports, was supposed to be of great extent and value; but the large masses, which characterized the mines soon gave out; and while mining has been continued more or less ever since, the yield has been comparat vely trifling.

VIRGINIA.—The only place in this State, from which corundum has been reported is Bull Mount, Patrick county. Here, in the fall of 1888, Mr. W. B. Rucker, of Stewart, Patrick county, discovered a few specimens of corundum and associate minerals.[1] The region is composed of mica-schist, talcose mica-schists and chloritic slates. Chrysolitic or serpentine rocks have not been observed in the neighborhood. It was thought, therefore, by Dr. F. A. Genth, who described the locality in the *American Journal of Science*, just cited,

[1] Am. Jour. Sc., 3d Series, Vol. XXXIX, p. 47, 1890.

that the corundum, which has only been found on the surface, belongs to several granite dykes, which intersect these schists. The minerals associated with the corundum are kyanite, andalusite, muscovite, margarite and chloritoid.

North Carolina.—This State takes the lead in the corundum industry, not only in the number of working mines, but also in the amount of corundum produced. Dr. Genth tells us:—"The first large mass was found in 1847 on the French Broad river, three miles below Marshall, in Madison (then Buncombe) county. It was of dark-blue color, and was associated with chlorite and margarite." In 1870, Rev. C. D. Smith sketched the corundum belt of North Carolina, as "running in a southwesterly course across Macon county, where it strikes the Georgia state-line, its general direction coinciding with the trend of the Blue Ridge, until it reaches the head of the Tennessee river, when it suddenly ceases on encountering the Nantegalee mountain (a spur of the Blue Ridge here running due north), to reappear 10 miles to the northwest on Buck Creek, whence it pursues its original course of northeast and southwest across the Chunkygal mountains, where it again enters the Blue Ridge.[1] Later investigation has revealed a more extended belt.

The last writing on the corundum deposit of the State is by E. W. Parker, in the United States Mineral Resources, 1893, who reports:—"The corundum is found in pockets and veins, usually from four to twelve feet wide, chiefly in gneiss, talc, chlorite and mica-schists, in massive anthophyllite, olivine or serpentinized rocks."

The principal mines are located in Macon, Jackson and Transylvania counties.

Georgia.—The gold washers knew of the presence of corundum in Georgia, "early in the forties;" but they paid no attention to it. About 1852, Mr. Plant, banker at Macon, Ga., sent a ruby, a small, red hexagonal prism, to Professor Shepard of Amherst College, which was said to have come from a gold mine in Habersham county, Ga. Similar brief mention, by writers of the period of 1870, place the knowledge of its presence in Georgia, at an early date in

[1] C. U. Shepard, Am. Jour. Sc., 3d Series, Vol. IV, 1872.

the American history of corundum; yet there seems to have been no systematic search made for the mineral, at this time. About 1870, Mr. William R. McConnell, of Hiawassee, Towns county, an enthusiastic explorer, found a considerable quantity of surface corundum on his estate; and, not knowing what it was, he piled it up for later determination. Shortly after, a specimen of this was shown to Rev. C. D. Smith, who immediately recognized it as corundum. About the same time, also, corundum was found by Mr. Thompson at Laurel Creek, Rabun county.

Interest, however, in Georgia occurrences was not fully awakened, until Dr. H. S. Lucas of Massachusetts opened up the Laurel Creek property. Since then, corundum has been searched for, in the northern counties, even by children.

South Carolina.—The corundum, found thus far in South Carolina, has attracted little attention. Its occurrence here is undoubtedly similar to that of North Carolina and Georgia. In the Resources of South Carolina, published in 1883, by the State Board of Agriculture [1], corundum is merely mentioned as a mineral occurring in Laurens, Anderson and Oconee counties in a mica-slate (?).

Alabama.—Dr. Eugene A. Smith, State Geologist, in answer to my letter of inquiry concerning the history of corundum in Alabama wrote:—"Corundum was first discovered in Alabama, near Dudleyville in Tallapoosa county about the year '72 or '73. The first notice of it was published by the Rev. C. D. Smith of North Carolina, who was searching for asbestos for a company. It has since been found in the neighborhood of Hanover, Coosa county. The Tallapoosa variety has been found only in loose pieces embedded in the soil, and has, as far as I know, not been found in place, there. It is associated with steatite, hornblendic and pyroxenic rocks, and, also, with tourmaline, asbestos and feldspar. In the Coosa county locality, the corundum appears to be enveloped in a thin coating of talc. Corundum has never been of any economic use in Alabama, principally for the reason, that the original vein has never been exposed, and nothing but more or less altered fragments have been obtained."

[1] South Carolina Resources etc., p. 137, 1883.

MONTANA.—According to Mr. G. B. Foote, one of the pioneers of Helena, corundum in the form of the precious stones, ruby and sapphire, was first discovered at Eldorado Bar, in December, 1865; but the earliest mention of finding sapphires in this State dates back to May 5, 1865, when Mr. E. R. Collins, an earnest and reliable prospector, found them on claim No. 4. Dr J. L. Smith called attention to this discovery in the *American Journal of Science*, in September, 1873.

The gems were discovered in the sluice boxes of the placer mines. In a short time, after having determined the limits of the precious stone bearing sands, a company was formed in London, under the title, "The Sapphire and Ruby Company of Montana, Limited," and the country was worked for both alluvial gold and precious stones. Since this time, the Montana fields have increased somewhat in importance, and are now recognized by the trade, as one of the sources for sapphires of medium grade, no true red rubies or true blue sapphires having been found. The rocks in the vicinity are limestone, quartzite and dark argillaceous slates. These are broken through and intersected by dykes, some of which have been described as mica-augite-andesite. In these dykes are found well defined crystals and rounded masses of sapphires, and other minerals. This, then, is the probable source of the innumerable sapphires, found in the alluvial deposits.

COLORADO.—Corundum was first found in this State in 1882, at the Calumet iron mines, situated in Chaffee county; this is the only locality known at present. It is found in small tabular crystals, mostly blue, though some are white. The crystals show the basal planes and rhombohedral faces, only; no prisms have been observed, in any instance. It occurs in siliceous and micaceous-schists, in which appear occasional pegmatitic bands. This has been metamorphosed, by intrusions of diorite. The associated minerals are quartz, feldspar, yellow mica, a little rutile and grains of magnetite. Mr. R. C. Hill, Geologist of the Colorado Fuel and Iron Company, Denver, to whom I am indebted for the information, says, that the "ore" is bunchy; but there seems to be a large quantity of it, the excavation showing it to extend one thousand feet on the outcrop.

At the time he wrote, they were having a car-load put through the concentrating mill, with a view to finding out what could be done with it.

CALIFORNIA.—No mention is made of corundum in the reports of the State Mineralogist. Dana, however, reports it, in Los Angeles county, in the drift of San Francisqueto Pass. Personal letters, from several of the leading mineralogists in the State, contain the same reply:—"The only knowledge we have of the occurrence of corundum in California is that, given in *Dana's System of Mineralogy*." It is evidently very rare.

NOMENCLATURE OF CORUNDUM.

The terms applied to the varieties of corundum are various, and have been much confused. This is accounted for, not only by the very early knowledge of this mineral, but, principally, from the fact, that only in the early part of this century were these varieties united under one head. Dr. Thomas Egleston,[1] of the School of Mines, Columbia College, has tabulated the following list of terms found in literature, past and present:—

CORUNDUM.

Adamant, *Kirwan.*
Adamantine spar, *Phillips.*
Adamas siderites, *Pliny.*
Alumina.
Anthrax.
Corindon, *Hauy.*
Corindon Adamantine, *Brongniart.*
Corindon Harmophane, *Hauy.*
Corivendum.
Corivendum, *Woodward.*
Corundite.
Demantspath, *Klaprath.*
Diamond spar.
Gyrasole, *Kirwan.*
Imperfect corundum, *Greville and Bournon.*
Karund, *Hind.*
Korund, *Werner.*
Rhombohedral corundum, *James.*
Rhombohedrischer corund, *Mohs.*
Soimonite.
Spath adamantine, *Delam.*
Thoneride.

[1] Catalogue of Minerals and Synonyms, by T. Egleston.

SAPPHIRE.

Hyacinthos, *Greek.*
Anthrax, Theophrastus.
Amethyste orientale.
Apyrote.
Asteria, *Pliny.*
Asteriated sapphire.
Asterie.
Barklyite.
Blue du roi.
Blue sapphire.
Carbunculus.
Cat sapphire.
Corindon harmophane.
Corindon hyalin, *Hauy.*
Corindon perfect.
Corindon telesie, *Brongniart.*
Emeraude orientale.
Hyacinth.
Hyacinthos.
Lichnis, *Pliny.*
Luchs saphir.
Luchs sapphire.
Lynx sapphire.
Opalescent sapphire.
Oriental amethyst.
Oriental aquamarine.
Oriental chrysolite.
Oriental emerald.
Oriental hyacinthe.
Oriental persodot.
Oriental ruby.
Oriental sapphire.
Oriental topaz.
Orientalisk rubin, *Wallerius*
Rubie etoile.
Rubin.
Rubis.
Rubis oriental, salamstein, *Werner.*
Salamstone.
Saphir, *Werner.*
Saphir asterie.
Saphir blanc.
Saphir de chat.
Saphir etoile.
Saphir.

EMERY.

Acone ex Armenias, Theophrastus.
Smiris.
Dioscorides.
Armenian Whetstone.
Corindon granuleux, *Hauy.*
Emeri.
Emeril, *Hauy.*
Emerite, *Shepard.*
Fer oxyde quartzifere, *Hauy.*
Granular Corundum.
Grinding spar.
Naxium.
Naxium ex Armenia.
Pyrites vivus, *Pliny.*
Schmergel.
Schmirgel.
Smiris, *Agricola.*
Smiris ferrea, *Wallerius.*
Smiris.

CHAPTER II.

VARIETIES OF CORUNDUM.

INTRODUCTORY REMARKS.

When the oxide of aluminum is found in the native state, it is known as corundum. The name corundum is derived from the Hindoo word *Kurand* (corundum stone)—corundum being probably first known in Europe from the Indian import. Three varieties of corundum are recognized, viz.: —

1. Sapphire,
2. Corundum,
3. Emery.

This classification was adopted early in the century, and the same is recognized in the arts to-day. Previous to this time, owing to differences in color, hardness, degree of transparency, and state of crystallization or structure, they were considered as distinct species. In 1805, they were united under one head by Hauy, although relationship of species in crystallization had been observed by the early crystallographer, Romé de Lisle.

The oxide of aluminum in its purest state is perfectly colorless and transparent; but it is seldom found in this condition ; corundum is generally tainted by some oxide of metal. The purer kinds of fine colors, transparent and translucent and useful as gems, are known as *sapphires;* the dull colors, not transparent, are called *corundum;* while the black or grayish-black variety intimately

mixed with oxide of iron, either magnetite or hematite, is distinguished as *emery*.

SAPPHIRE.

The variety termed "Sapphire" includes all those kinds of corundum, which, on account of their purity in color, transparency and translucency, may be used as gems. Under this head, therefore, are grouped many stones having individual names. For simplicity in classification, jewelers have adopted the following table. It will be observed in this table that shades of red are classified as "Rubies," while any other color, or those destitute of color, pass under the head of "Sapphire":—

JEWELER'S CLASSIFICATION OF SAPPHIRE.

Sapphire.		Ruby.	
True Sapphire	blue.	True Ruby or Oriental Ruby	red.
Sapphire	shades of blue.	Anthrax (Theophrastus)	red.
Sapphire, (Diamond Spar)	white.	Carbunculus	red.
Sapphire, (Adamas, Pliny)	white.	Lychnis (Pliny)	red.
		Ruby	shades of red.
Oriental Topaz	yellow.	Oriental Amethyst	purple.
Oriental Emerald	green.		
Star Sapphire	Asteria (Pliny).		

Ruby.—This is pre-eminently the most important of the "precious stones" of this species. Its marvelous beauty, which induced worship from the ancients, has ever awakened an allied feeling in the hearts of Christians. Stones of true "pigeon's blood" color are extremely rare and valuable. Burma, Siam and Ceylon are practically the only commercial fields; and, of these, Burma alone has become celebrated for the production of the true color, though occasionally fine gems are found both in Siam and Ceylon. According to Mr. Edwin W. Streeter,[1] their original matrix was probably crystalline limestone, the disintegration of which has left them distributed along the hills and valleys and on the floor of limestone caverns. The typical ruby-bearing earth seems to be a yellowish clay, known locally as *Byon*.

[1] Any one interested in the study of gems will be well repaid to read his admirable work entitled "Precious Stones and Gems," 5th edition, published by George Bell & Sons, Covent Garden, London.

The value of rubies of true color depends largely upon judicious cutting, size and flawlessness. A perfect ruby of one carat weight, or more, has always taken precedence of the diamond in value. Of the two, equally perfect and five carats in weight, the ruby will bring ten times the price of the diamond. Above ten carats, the value of such a ruby is inestimable. This may be better illustrated by a well known sale, in which the rubies were considered to have been sold at a great loss. In 1875, the necessities of the Burmese Government compelled it to sell to the London market two rubies, which connoisseurs pronounced the finest ever seen. They weighed, when recut, one 32 5-16, the other 38 9-16 carats. They were sold for $50,000 and $100,000, respectively.

SAPPHIRE.—The sapphire was ranked by the ancients, almost as high, if it was not held in quite as close esteem, as the ruby. To it, as to the ruby, they ascribed wonderful properties, and prized it exaltedly. As with the ruby, commerce knows only of a few localities, in which it is found in sufficient abundance to pay for mining. These are Siam, Burma, Cashmere and Ceylon, Siam yielding the most beautiful and perfect stones. Owing to large finds, which have been made in the East, within the last fifteen years, the sapphire has greatly depreciated in value, though exceptionally fine stones are still highly prized.

The finest sapphire in the world came from India. It is a richly colored blue stone, and weighed, on arrival in Europe, 225 carats. Owing to a flaw, it was recut into a gem of 165 carats. This was sold in Paris, and was estimated to be worth from $35,000 to $40,000.

STAR SAPPHIRES.—There are certain varieties of corundum, which show a stellate "opalescence," or a star of light, when viewed in the direction of the vertical axis of the crystal. This is especially true of the grayish-blue translucent sapphires. Furthermore, there are purple and reddish shades of ruby, which, when properly cut, also show this asterism. Stones of such character are known as "Star Sapphires."

The optical phenomenon here presented is due to the internal structure of the stone. All star sapphires show the laminated

structure, and, on the basal planes, lines radiating from a common center. The action of the light on these radiating lines gives rise to a star-like opalescence, which is very attractive. Star sapphires have increased in value in the past few years ; but this value is very small, unless they are of finest rank and color. Small star sapphires range from ten dollars upward. The finest star ruby, lately seen in England, was valued at $10,000.

How to Select Sapphires.—In the selection of sapphires, one must guard particularly against imperfections ; for the sapphire is typically imperfect. An examination, in person, of a first-class jeweler's collection of sapphires, revealed, out of a hundred stones, only two or three free from defects. The common defects are an imperfect transparency, clouds, spots partially opaque, massing of color at one spot, fine dark lines, white glassy stripes, rents, knots and silky flakes on the table of the stone. These defects are frequently observable to the naked eye ; but their presence is rendered more evident by the use of a lens. An expert gem-cutter will so cut a sapphire, with its color massed at one spot, as to cause the color to be dispersed by the reflection of the light against the facets. The color of the sapphire is often merely a matter of taste ; yet, to the trade, color is most important, and "true colors" are recognized. The most valuable ruby has the color of "pigeon's blood," while the true sapphire must have the characteristic velvety appearance of the blossom of the little "corn flower."

CORUNDUM.

The variety, corundum, includes all semi-transparent and translucent kinds of corundum, not useful as gems; also, all the dull and opaque kinds, except emery. Three types are commonly distinguished in mines, viz: —

1. Sand-Corundum.
2. Block-Corundum.
3. Crystal-Corundum.

Sand-Corundum.—This is a granular corundum, coarse or fine, usually found embedded in a gangue of vermiculites or of decom-

posed feldspar. In some veins, it occurs free, while in others, alteration or associate minerals, commonly albite, margarite or damourite (a variety of muscovite), wrap it closely, forming a crust, which frequent washing will not remove; a machine for the purpose is required. Sometimes, it is penetrated by vermiculite scales. The color of sand-corundum is usually gray to grayish-blue, although red is common, and all the other colors may be detected. This is much the most productive of corundum found, and, therefore, the most worked. Moreover, veins of this character seem universally present in corundum mines.

Block-Corundum.—This includes the massive corundum with nearly rectangular parting or pseudo-cleavage. The largest specimen of this kind, known to have been found, was taken from the Laurel Creek mine, Rabun county, Ga., and was said to weigh over 5,000 pounds; other immense blocks have been taken from the same mine, on account of which the mine is frequently called a "block-corundum mine." Veins, however, of this character, that is, in which the corundum is massed in such large bodies, although extremely rich at times, are usually abandoned as non-paying.

Crystal-Corundum.—Crystal corundum is quite common, and includes all corundum possessing crystal form. It is present, with both the sand and the block-corundum, and ranges in size from very minute crystals to those of magnificent proportion. Among the largest crystals ever found were some, which were taken from the so-called block-corundum veins at Laurel Creek mine, during the summer of 1893; they are now in the possession of Dr. H. S. Lucas. A description of these is given with figure 2. Corundum crystals are usually rough, and seldom transparent; this is especially true of large crystals. Frequently, moreover, the large crystals do not possess a uniform color; but patches of gray, blue and red tints blend into each other. The most common type in Georgia and North Carolina are six-sided prisms, usually with the basal plane, and quite frequently terminated by a pyramid. Fuller particulars on these types will be omitted, to avoid repetition, later.

FIG. 2.

1 2

Large Corundum Crystals from the Laurel Creek Corundum Mines, Rabun County, Georgia. 1. Height, 14 inches, diameter, 8½ inches. 2. Height, 16 inches.

EMERY.

Emery is an intimate mixture of corundum and magnetite or hematite. It is without crystal form, and has the appearance of a fine grained iron ore, which it was thought to be, for some time. Its hardness is due to the presence of corundum; and this, together with its abundance, makes it very desirable as an abrasive agent. Emery has been supplied to the world many years from the Grecian islands, where it has been known and used, for thousands of years. Here it is found in a bluish metamorphic marble, interbedded with mica-slate and gneiss. Its occurrence is in the form of nodules and large irregular masses, some of which are several yards in diameter and up to forty tons in weight. These large pieces, unless fissured, are broken with great difficulty, on account of the compactness of the grain. Since the transportation from the quarries is only on the backs of horses and camels, those masses which will not yield to the hammer are exposed to the action of fire for several hours, and are thus broken up. Dr. J. Lawrence Smith's investigations for the Turkish Government, and his discoveries of 1847, so increased the known area of emery in that region,

that the monopoly, exercised by the owners of the Greek property, was completely broken, and the price was reduced more than one-third. Following Dr. Smith's discoveries, and consequent, in a great measure, upon his able reports on the geological relations, emery was discovered in other parts of the world. In the United States, in 1863, Professor Jackson discovered a vein of emery at Chester, Mass.[1] The greater portion of emery, however, used in this country comes from the Grecian islands, and is known to the trade as Naxos emery or Turkish emery. "For the decade ending with 1878, our average annual import of emery ore was 2,376,743 pounds. For the decade ending with 1888, it was 7,315,165 pounds, the year 1888 showing the largest total of any year but one, during twenty years. That total was 9,643,800 pounds. While the annual import of ore was more than tripled in the second decade, the annual average import of granulated and pulverized emery slightly decreased. That annual average import was for the first decade 621,807 pounds, and for the last, 589,054 pounds. The total annual average import of ore and grain for the first decade was 1,338 tons, and for the second, 3,521 tons."[2] It will be seen, by table on page 113, that the increase has been, on the average, continuous up to date.

Very little emery has thus far been found in North Carolina, and none in Georgia. In 1893,[3] emery was discovered on Skeena creek, five miles from Franklin, Macon county, North Carolina. The abundance of the deposit has not been reported.

PHYSICAL AND CHEMICAL PROPERTIES.

Chemical Composition.—The formula for corundum is written Al_2O_3. Sapphire and common corundum are considered essentially pure oxides of aluminum, while emery is an intimate mixture of corundum with an oxide of iron, either magnetite or hematite.

[1] See this report, under Massachusetts, p. 15.

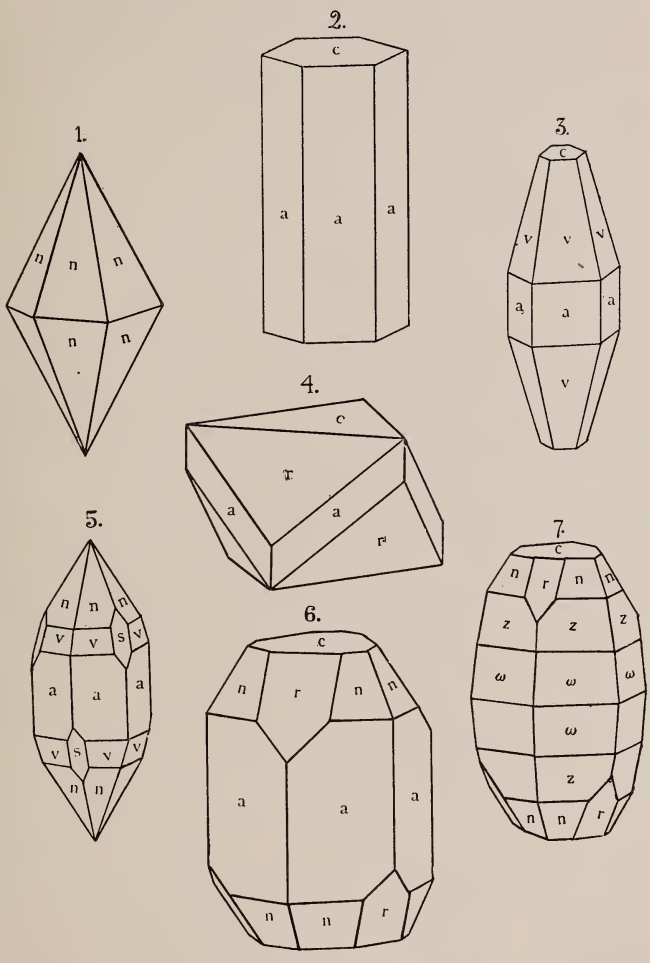
[2] T. Duncan Paret; Journal of the Franklin Institute, March, 1890.

[3] Mineral Resources of the U. S., 1893, p. 675.

Analyses of corundum and emery, made by Dr. J. Lawrence Smith, are as follows:—

No.	LOCALITY.	Effective Hardness. Sapphire, 100.	Specific Gravity.	COMPOSITION.				
				Water.	Alumina.	Magnetic Oxide of Iron.	Lime.	Silica.
	EMERY.							
1	Kulali	57	4.28	1.90	63.50	32.25	0.92	1.61
2	Samos	56	3.98	2.10	70.10	22.21	0.62	4.00
3	Nicaria	56	3.75	2.53	71.06	20.32	1.40	4.12
4	Kulali	53	4.02	2.36	63.00	30.12	0.50	2.36
5	Naxos	46	3.75	4.73	58.53	24.10	0.86	3.10
6	Nicaria	46	3.74	3.10	75.12	12.06	0.72	6.88
7	Naxos	44	3.87	5.47	69.46	19.07	2.81	2.41
8	Ephesus	42	4.31	5.62	60.10	33.20	0.48	1.80
9	Kulali	40	3.89	2.00	61.05	27.15	1.30	9.63
	CORUNDUM.							
1	Sapphire of India	100	4.06	....	97.51	1.89	....	0.80
2	Ruby of India	90	....	....	97.32	1.09	....	1.21
3	Corundum, Nicaria	77	3.88	1.60	92.39	1.67	1.12	2.05
4	" Asia Minor	65	3.92	0.68	87.52	7.50	0.82	2.01
5	" Asia	60	3.60	1.66	86.62	8 21	0.70	3.85
6	" India	58	3.89	2.86	93.12	0.91	1.02	0.96
7	" Asia	57	3.80	3.74	87.32	3.12	1.00	2.61
8	" India	55	3.91	3.10	84.56	7.06	1.20	4.00
	EMERY.							
1	Chester, Mass	33	....	....	44.01	50.21	....	3.13
2	" "	40	....	....	50.02	44.11	....	3.25
3	" "	39	....	....	51.92	42.25	....	5.46
4	" "	45	....	....	74.22	19.31	....	5.48
5	" "	..	....	....	84.02	9.63	....	4.81

FIG. 3.



CRYSTAL FORMS OF CORUNDUM.

Crystal Form and Structure.[1]—Corundum crystallizes in the Rhombohedral Division of the Hexagonal System. The crystals are usually doubly terminated, six-sided pyramids or six-sided prisms, terminated by the basal plane, and, not unfrequently, they are in tabular crystals or six-sided plates. The pyramidal and prismatic faces are more or less deeply striated or grooved horizontally. The basal planes or truncated ends of the crystals are striated parallel to the edges, or divided into sectors by lines radiating from the center. The latter, when cut *en cabochon*, that is with a convex face simply polished, reflects, from the convex surface, a star of light (asterism). If the crystals are large they are usually rough and rounded. Most specimens found are rolled pieces and fragments. It also occurs massive in coarse and fine grains. Twins occur, either as penetration or polysynthetic forms, most frequently the latter. In both cases, the twinning-plane is the rhombohedron. When the twins are polysynthetic, that is, when the twinning-planes of the aggregate of individuals continue parallel to each other, a laminated structure is produced. This structure gives rise to the pseudo-cleavage or parting, so common in corundum.

Cohesion.—Cleavage is due to minimum cohesion. In corundum there is no true cleavage, but a pseudo-cleavage, due to parting. Parting should be clearly distinguished from cleavage. Cleavage is the natural fracture along the plane of minimum cohesion or least resistance ; parting is a plane, in which the cohesion is minimum, because the structure is lamellar through twinning, or in which the cohesion has been reduced to a minimum by pressure. Parting in corundum is sometimes perfect, but interrupted, parallel to the basal plane. There is also a parting parallel to the rhombohedron. The former parting is due to pressure, and the latter to twinning.

Corundum is extremely brittle, except when compact; then it is tough. A broken surface shows an uneven to conchoidal fracture.

[1] The best text-book in English on crystallography is published by Henry Holt & Co., New York City, entitled, " Elements of Crystallography," by Dr. George H. Williams, late Professor of Geology at Johns Hopkins University. Those, interested in the collection and study of minerals, and who desire more information on crystal structure, than is commonly found in mineralogies, will do well to provide themselves with this little book.

The hardness of corundum is 9.[1] It will be seen, by the table of analyses made by Dr. Smith,[2] that there is a considerable difference in hardness between different varieties of corundum, and between specimens of the same variety from the same or different localities. This will be considered in the chapter on economics.

SPECIFIC GRAVITY.—The density of corundum, as compared with that of water as a standard, assumed to be 1, varies but slightly from 4. This quantity is not constant, owing to the variations in chemical composition and physical structure.

OPTICAL PROPERTIES.—The luster of emery is metallic, or the luster of metal; of the other varieties of corundum, it is adamantine [3] to vitreous.[4] The color of corundum varies, not only in different localities, but in the same locality—ranging from white to brown, viz., white, gray, blue, red, yellow and brown. Emery is dark-blue to black; its streak is uncolored. Pleochroism, or that property, which certain minerals possess of showing a different color, when light is transmitted through a crystal in different directions, is observed in the deeply colored specimens of sapphire. Spinel and garnet, minerals often confused with sapphire, do not possess this property on account of their crystalline character; and hence, by means of the dichroscope, an instrument so constructed, that the result of light transmitted in two directions may be compared side by side, this

[1] Many minerals, which, to the average observer, resemble each other closely, may be readily distinguished by their hardness. This is especially true of corundum, and minerals bearing a striking resemblance to it. Mohs has made out a table of ten minerals, with which all minerals are now compared. The determination is made by the resistance a smooth surface offers to scratching. It may be well to state, in regard to the following table, that there is a greater difference between corundum and diamond, than between talc and corundum, a break, which we have no known natural minerals to bridge.

MOHS' SCALE OF HARDNESS.

1. Talc.	6. Feldspar.
2. Gypsum.	7. Quartz.
3. Calcite.	8. Topaz.
4. Fluorite.	9. Corundum.
5. Apatite.	10. Diamond.

[2] See page 30.

[3] The luster of the diamond.

[4] The luster of broken glass.

distinction can be readily made. The diaphaneity [1] of sapphire varies from transparent to translucent; of corundum, from translucent to opaque; while emery is opaque. The index of refraction [2] of corundum is 1.76. This high index of refraction accounts for the great brilliancy, when the gems are properly cut and polished.

ARTIFICIAL PRODUCTION OF CORUNDUM.[3]

Synthetical mineralogists discovered some years ago, that the pure forms of corundum could be reproduced artificially. Increase in knowledge in synthetical chemistry, in the past ten years, has enabled workers in this field to effect the most admirable results in the case of corundum, not only in the production of sapphires, but also in the size of the crystals produced. Gaudin, by means of charcoal, decomposed potash-alum and formed corundum. Ebelmen, by exposing four pints of borax and one of alumina to a high heat, produced crystals of corundum. The result of Deville and Caron's works (the subjection of aluminum to the action of boric acid in a carbon vessel) was corundum, in large rhombohedral plates; the addition of chromium fluoride, in varying amounts, gave color, affording blue, red and fine green sapphires. Meunier obtained corundum by the decomposition of aluminum chloride by magnesium and water vapor, at a high temperature in a sealed tube. Fremy and Feil fused alumina and minium in siliceous earthen crucibles, obtaining "a fusible lead aluminate, which was subsequently decomposed by the silica, setting free the alumina in hexagonal crystals of considerable size, under varying conditions, rubies, sapphires etc., being obtained." "Friedel [4] describes the production of crystals of corundum and diaspore by the wet way, by the action of a solution of soda and amorphous alum, at an elevated temperature. At 450° to 500°, both corundum and diaspor were obtained; at 530° to 535°, only corundum; and at 400°, only diaspore." Fremy, in *Synthese du Rubis*, describes the successful reproduction of rubies by the reaction, at a high temperature, in an earthen

[1] Degree of transparency.

[2] Power of refracting light.

[3] Dana's System of Mineralogy, sixth edition, p. 213.

[4] Dana's System of Mineralogy, sixth edition, p. 1031.

vessel, of a mixture of alumina, with more or less potash, upon barium fluoride, bichromate of potassium being used as coloring matter. The result was rubies well crystallized, clear and of brilliant luster.

CHAPTER III.

ALTERATIONS AND ASSOCIATE MINERALS OF CORUNDUM.

GENERAL OBSERVATIONS.

Corundum undergoes many alterations, which give rise to a series of interesting aluminous minerals. Our knowledge of these minerals, in their relation to corundum, is extremely limited, because of the few workers along this line of investigation, and the difficulties, under which they have labored. This is especially true of the United States, where so few places have been opened up to the investigator, that his scope for careful and comparative study has been rigidly limited, and good material, rare. To Dr. J. Lawrence Smith, and to Dr. F. A. Genth, especially, who made quite an elaborate study of corundum alteration products, we are most indebted for our knowledge of these minerals.[1] As far as known, some of these minerals have not been observed in Georgia, while others, although undoubtedly present, have not yet been differentiated from the group. Nevertheless, descriptions of the most important ones will be an aid to those interested only in mineral

[1] In the discussion of these minerals, the work of both men is used freely.

collection, while to those citizens prospecting for corundum, a knowledge of these minerals will be invaluable, as a guide and clue to the presence of that mineral, on account of their intimate relations to it.

OXIDES OF SILICON.

Quartz, Chalcedony, Opal.

QUARTZ.—Quartz crystals occur penetrated by corundum. Sillem [1] has observed quartz pseudomorphous after corundum.

CHALCEDONY.—This is a cryptocrystalline [2] form of quartz. Usually it is white, grayish-white or brown; other colors have special names. In mammillary and botryoidal forms, it is quite common, as an associate of corundum.

HYALITE.—This is a variety of opal, an amorphous [3] form of silica, with a varying amount of water. It has the chemical composition of quartz plus water; but its opal condition renders it less hard, with a lower degree of specific gravity, and without power of crystallization. It has been found at Corundum Hill, Macon county, N. C., as a botryoidal, colorless and white incrustation upon foliated chlorite and upon corundum; also, of a brown color, upon corundum at Dudleyville, Ala.

HYDROUS OXIDES OF ALUMINUM.

Diaspore, Bauxite, Gibbsite.

DIASPORE.—Diaspore is a hydrated aluminum oxide, with the formula, $Al_2O_3.H_2O$ = alumina 85.0, water 15.0. Crystallizing with orthorhombic symmetry, it occurs in prismatic crystals, foliated masses, in thin scales, and sometimes in stalactitic forms. The crystals are usually flattened, sometimes acicular, with commonly rounded faces and vertical striations. It is usually not quite as hard as quartz, nor as heavy as corundum. The cleavage is very perfect, parallel to the flattened, prismatic face. The luster is brilliant, while the color is a very light shade of green, gray, brown or

[1] Sillem. Leonhaide and Brouns, Jahrbuch, p. 385, 1851.

[2] Flint-like.

[3] Incapable of crystallization.

yellow, to colorless. Beautiful specimens have been found at Chester, Mass., and at Unionville, Chester county, Pennsylvania. It has also been observed at Corundum Hill, N. C.; and, at the Laurel Creek corundum mine, in Rabun county, Ga., it occurs in small tabular, transparent, white crystals, as an associate of the corundum. Dr. Genth considers it a result of the hydration of corundum, and asks, if, like corundum in spinel, it may not be so minutely distributed, as to be concealed to the sharpest investigation. Dr. J. Lawrence Smith, in his Scientific Researches, p. 27, says:—"There is reason to believe, that the mineral will be found in almost every corundum locality." Like Dr. Genth, he thinks, from the fact that, when imbedded together, the line of gradation is imperceptible, that diaspore may be so intimately mixed with some corundum, as to escape detection; and hence, by means of it, he would explain the presence of water in many corundums.

BAUXITE.—This mineral is of especial interest in Georgia, because the Coosa valley of Georgia and Alabama is one of the two localities in the United States, which yield bauxite in commercial quantities; the other is the Arkansas locality. The former region was briefly described by Dr. C. Willard Hayes,[1] Assistant United States Geologist, in a paper read before the Virginia Beach meeting of the American Institute of Mining Engineers, February, 1894. Reports upon the same region, also, have been made by Henry McCalley,[2] Assistant Geologist of Alabama, and Dr. J. W. Spencer.[3]

J. W. Hawkins's work near Hermitage, Floyd county, Ga., in 1887, was the first mining of the kind done in America; and, up to October, 1891, 4,000 tons[4] had been taken out of one pit without reaching the bottom of the deposit. This deposit is one of many lying in a narrow belt, which extends from Adairsville, Ga., about sixty miles, to the vicinity of Jacksonville, Ala. Besides the de-

[1] The Geological Relations of the Southern Appalachian Bauxite Deposits; C. Willard Hayes, Trans. Am. Inst. of Mining Eng.

[2] Alabama Bauxite; by Henry McCalley, Proc. Ala. Indus. and Sci. Soc., 1893.

[3] Geology of the Paleozoic Group of Georgia; J. W. Spencer, 1893.

[4] Geology of the Paleozoic Group of Georgia; by J. W. Spencer, 1893, p. 228.

posit just mentioned, this mineral has been worked on a commercial scale at two points near Rome, Ga.; one, five miles north, the other, six miles south of Rome; it has also been worked near Rock Run, Ala. Dr. Spencer says:[1]—"The quantities of the Georgia bauxite are extensive; and, with the increasing demand, a large supply can be obtained."

Bauxite occurs, either in round grains, disseminated or compact, or as earth and clay-like matter. The color depends upon the extent of iron staining, and is white, grayish, ochre-yellow, brown and red. Bauxite is another form of hydrated alumina; and it so closely resembles diaspore in composition, as to be given the same chemical composition by some authors. Dana, in his formula, however, doubles the amount of water. Ferric oxide is usually present; sometimes, in large amount, replacing the alumina; at others, as an impurity.

To be marketable, bauxite must contain not more than 3.5 per cent. of iron or 20 per cent., or thereabouts, of silica; nor must it contain less than 55 per cent. of alumina. Titanic acid is generally present in the Coosa valley bauxite; but this is not objectionable. Spencer, in his chapter on aluminum, in volume just cited, has given the following analyses of bauxite from the belt in Georgia : —

ANALYSES OF GEORGIA BAUXITE.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Alumina.	46.72	52.13	39.75	56.10	58.61	43.18	36.86	59.82	51.22	53.31	45.21	61.25	67.53	60.61	60.63	68.82
Ferric Oxide.	2.14	1.12	1.62	10.64	2.63	8.74	1.28	2.16	4.83	12.92	0.52	1.82	trace.	0.21	trace.	0.21
Silica.....	29.01	19.56	41.47	2.56	8.29	28.11	40.02	6.62	13.31	1.16	35.88	1.98	2.92	4.18	4.76	2.13
Water.....	20.15	24.21	16.14	30.10	27.42	19.22	20.64	31.10	29.82	29.60	17.13	31.43	1.34	2.47	3.20	4.04
Titanic Acid.	0.87	2.08	.....	.....	3.15	.....	.....	.....	.....	3.22	.....	2.38	28.00	32.00	31.00	31.50

No single hypothesis has yet been offered to explain acceptably all occurrences of bauxite. The bauxite of Southern France apparently originated by the breaking down of basalt and its subsequent residual deposition. The origin of the Arkansas deposits, which occur in well stratified beds in tertiary rocks, is connected, by

[1] Geology of the Paleozoic Group of Georgia; by J. W. Spencer, 1893, p. 223.

State Geologist Branner, with the contact eruptives; while the Georgia deposits, Dr. Spencer evidently considers, to have been formed by the precipitation of alumina "in the lagoons, in which the ferruginous and manganiferous clay-limestones were being formed." The alumina, he considers, to have been derived from the weathering of the country rocks. Dr. Hayes, on the other hand, who has made an admirable map of the region, and given it much study, finds[1] the deposits of the Coosa valley to be directly upon faulted contacts, and concludes that "such enormous dislocation of the strata generated a large amount of heat. The fractures facilitated the circulation of water; and, for considerable periods, the region was probably the seat of many thermal springs. These heated waters appear to have been the agent, by which the bauxite was brought to the surface in some soluble form, and there precipitated." This accords with the theory of Auge, who has called attention to the formation of hydrated alumina in the Yellowstone region.

The association of bauxite with corundum has been noted in the bauxites of Southern France. Here occasional grains of corundum have been observed enclosed by bauxite. This called forth the interesting remark from T. Sterry Hunt,[2] that sufficient heat will convert bauxite into corundum, and that these grains of corundum encased in bauxite would seem to show, that even, at ordinary temperatures, the change may take place. Dr. Genth[3] denies this flatly, saying that, on the contrary, this proves quite conclusively to him, that the presence of corundum in the bauxite shows the bauxite to be the alteration product of corundum.

Attempts have even been made, to explain, by common origin, the bauxite and corundum formations of Georgia on the ground, that the corundum belt is a direct continuation of the bauxite belt. In conclusion, I might say, that, whatever may be the relation between corundum and bauxite in Southern France, any attempt to

[1] The Geological Relations of the Southern Appalachian Bauxite Deposit; by C. Willard Hayes—Trans. Amer. Inst. Min. Eng., 1894.

[2] T. Sterry Hunt, Amer. Jour. of Sc., 2nd series, Vol. XXXII, p. 288.

[3] Contri. from Lab. Univ. Pa., No. 1, F. A. Genth, p. 13.

harmonize the two belts in Georgia must show an utter failure, to appreciate their wide differences in geological relations.

GIBBSITE.—This is a rare mineral, and has been observed only in two localities, in connection with corundum. Dr. Smith[1] mentions two specimens of hydrargillite (an old name for gibbsite) from Gumuch-dagh, one a hexagonal prism, the other coating a crystal of corundum. The former, Dr. Genth, presumes to have been a pseudomorph after corundum. T. S. Seal[2] found at Unionville, Pa., gibbsite in the form of mammillary crustations, coating albite.

The composition of gibbsite is given as $Al_2O_3.3H_2O$ = alumina, 65.4, water, 34.6. It crystallizes in the monoclinic system, in a tabular form. It also occurs in stalactitic, mammillary and incrusting forms. It is tough, with an eminent cleavage parallel to the basal plane. The color is white, grayish, greenish or reddish-white. When breathed upon, it has a clayish odor.

Dr. Spencer[3] mentions the occurrence of stalactitic, mammillary and incrusting forms, found on the Barnsley estate, Floyd county, Ga., in connection with bauxite. It has not yet been seen in any *corundum locality* in this State.

ANHYDROUS OXIDES OF OTHER METALS.

Spinel, Hematite, Rutile, Ilmenite, Titanite.

SPINEL.—Spinel is the name given to a mineral of the Isometric system, whose formula is $MgAl_2O_4$, it being one of the principal species of the spinel group, which bears its name. Of its four varieties, *ruby spinel* is a common associate with the true ruby; *picotite* is common in peridotites and the serpentine derived from them; and *hercynite* has been described by Professor G. H. Williams, as an associate of magnetite and corundum, in the "Cortlandt Series."

The spinel of Corundum Hill, Macon county, N. C., is generally massive, coarsely to finely granular, and black or dark-

[1] Scientific Researches; J. Lawrence Smith, page 26.

[2] T. S. Seal, Amer. Jour. of Sc., 2nd series, Vol. XI, page 267.

[3] Geology of the Paleozoic Group of Georgia; J. W. Spencer, 1893, page 213.

green in color. It has been found to be mixtures of several spinels. From this locality, Colonel Joseph Willcox, of Philadelphia, has a pseudomorph of black spinel after corundum, the crystal being enclosed in a foliated chlorite. At Dudleyville, Tallapoosa county, Ala., black spinel, surrounded by patches of yellowish-white, cleavable corundum, occurs in chlorite.

GAHNITE, a zinc spinel, with the formula, $ZnAl_2O_4$, was observed by Dr. Smith in association with the corundum at Gumuch-dagh, Asia Minor.

MAGNETITE, the proto-sesquioxide of iron, $FeO.Fe_2O_3$, forms a part of most emery, and is present in the country rocks.

CHROMITE, $FeCr_2O_4$, the principal ore of chromium, is seldom absent from the chrysolites of corundum formations, where it occurs as a constituent of the rocks, in veins, in bedded masses, and disseminated in minute crystals through the chrysolite. Embedded masses of it occur at Hog Creek, near Hiawassee, Towns county, Ga., where it is encrusted with genthite.

HEMATITE.—Hematite is sometimes associated with corundum, as an intimate mixture, forming in part the variety of corundum known as emery.

RUTILE.—This is a rare associate of corundum.

ILMENITE.—This mineral is found associated with corundum in New York State; also at Chester, Mass. With it are generally present rutile, spinel etc.

TITANITE.—This mineral is, in rare instances, an alteration product of rutile and ilmenite; hence it is sometimes present with corundum.

ANHYDROUS SILICATES.

Enstatite, *Anthophyllite*, *Amphibole* (Tremolite, Actinolite, Asbestus, Smaragdite), *Chrysolite*, *the Feldspars*, *Zoisite*, *Fibrolite*, *Kyanite*, *Tourmaline*, *Staurolite*.

ENSTATITE.—Good specimens of enstatite have been found at the various corundum mines in North Carolina, associated with corundum. Enstatite is an orthorhombic member of the pyroxene group, having the formula, $MgO.SiO_2$ = Silica 60, magnesium 40 = 100 ;

sometimes a little iron is present with the magnesium. In color, it is grayish-white, yellowish-white, greenish-white to olive-green and brown, according to its percentage of iron. Distinct crystals are rare, and of prismatic habit. It usually occurs massive, fibrous or lamellar.

ANTHOPHYLLITE.—This mineral crystallizes in the orthorhombic system, and is an orthorhombic member of the amphibole group. It is a magnesium ferrous silicate $(Mg,Fe)SiO_3$, and corresponds to enstatite, bronzite and hypersthene of the pyroxene group. Crystals are rare, and of prismatic habit. In association with corundum, it is commonly lamellar or fibrous massive, often occurring in forms resembling asbestus. It forms part of most corundum-bearing formations, as massive rock, in which anthophyllite is frequently radially arranged with actinolite. The color of anthophyllite is usually of a brownish shade, sometimes of a clove-brown, from which its name is derived.

TREMOLITE.—Tremolite is a calcium-magnesium variety of the species, amphibole ; its formula is $Ca\ Mg_3\ Si_4O_{12}$ = silica 57.7, magnesia 28.9, lime 13.4 = 100. Ferrous iron replacing magnesium is frequently sparingly present, only up to 3 per cent. It crystallizes in the monoclinic system in distinct crystals, which are often in thin, flat blades. It is white to dark-gray in color, and sometimes transparent and colorless. Tremolite has been distinguished at various corundum mines in North Carolina, and at the Laurel Creek corundum mine in Rabun county, Ga.

ACTINOLITE.—Actinolite, another variety of the amphibole species, has been distinguished at all the Georgia corundum properties. It occurs also in the Pennsylvania and North Carolina corundum localities. It is a calcium-magnesium-iron amphibole, with the formula, $Ca(Mg,Fe)_3\ Si_4O_{12}$. Its color, due to ferrous iron, is bright-green and grayish-green. It crystallizes in the monoclinic system. The crystals are common, either short or long bladed, as in tremolite ; it also occurs columnar, fibrous and granular-massive. Beautiful specimens of bright-green columnar crystals, several inches in length, and often fully one third of an inch in width (longest horizontal axis), are found in talc, south of Ac-

worth, Paulding county, and near Monroe, Walton county, Ga. Talc is the most frequent matrix of this mineral.

Asbestus.—Tremolite, actinolite and other varieties of amphibole (except those containing much alumina), when so fibrous that the fibers are threadlike, are called asbestus. Chrysotile, the fibrous variety of serpentine, is often confused with, and is much used as, asbestus. It is distinguished from asbestus, however, by the presence of water. Being fire-proof, and the finer grades being so easily woven into cloth, asbestus has been used for centuries. Pliny speaks of it as a "vegetable growth," and says that it is good for making incombustible cloth. The ancients had high regard for asbestus, because the cloth made from it could be easily made undefiled by throwing it into fire, and thus purifying it.

Asbestus is present in many of the corundum properties in this State; but, as far as observed, it is of an inferior quality. The fibers, though long, are without strength, and when a mass is exposed to the air, it becomes very hard on account of the presence of hydrous-iron sesquioxide, which has seeped into it. Various properties have been prospected for asbestus, and considerable of the material has been shipped; but industries of this nature have never continued longer than a few months. In Nacoochee Valley, White county, a large plant has just been established, and "asbestus rock," as they call it, is being "defiberized" for the market.

Smaragdite.—A rock, formed of a grass-green hornblende, feldspar and grains of pink to deep ruby corundum, has attracted considerable attention, because of its beauty and its occurrence in only a few corundum localities of North Carolina and Georgia. This grass-green mineral was, and is now, commonly called *smaragdite*. Charles Upham Shepard, Sr.,[1] speaks of it as *arfvedsonite*, to which it bears no resemblance. Dr. Genth, from an analysis, by Chatard, of a representative specimen from Cullakenee Mine, North Carolina, calls it *kokscharoffite*, after an aluminous amphibole. According to the last edition of Dana's System of Mineralogy,[2] sma-

[1] Corundum Region of North Carolina and Georgia, by C. U. Shepard, Sr., Amer. Jour. Sci., 3rd series, Vol. IV., Aug. and Sept., 1872.

[2] The System of Mineralogy of James Dwight Dana, sixth edition, by Edward S. Dana, 1892.

ragdite is "a thin, foliated variety of amphibole, near actinolite in composition, but carrying some alumina. It has a light grass-green color, resembling much common green diallage." As a variety, based on color, this mineral has as much claim on mineralogists as hiddenite and other similar varieties.

CHRYSOLITE.—This mineral usually occurs in embedded grains with chromite, forming the so-called "chrysolite formations," in which the corundum of this region occurs. It crystallizes in the orthorhombic system, with crystals often flattened, and sometimes elongated. The cleavage is rather distinct in one direction, but less so in another, while the fracture is conchoidal. The color, as found in this region, is usually olive-green. The chemical formula is $2(Mg, Fe)O.SiO_2$, in which the magnesium and iron vary widely. Titanium dioxide, tin and nickel are sometimes present in small quantities. It is infusible in most cases; but it is decomposed by hydrochloric and sulphuric acids, with the separation of gelatinous silica.

THE FELDSPARS.—The feldspars, which are present in corundum localities, belong to the plagioclase species, or lime-soda feldspars, that is, albite and anorthite, and their isomorphous mixtures. The chemical composition of the theoretical albite is $Na_2O_3.Al_2O.6SiO_2$; that of anorthite is $CaO.Al_2O_3.2SiO_2$. All the other lime-soda feldspars are isomorphous mixtures of albite and anorthite = $Ab_n An_m$. A few, which occur most frequently, have received particular names. Tschermak has brought these together into a table, which may be enlarged by the addition of any of their compounds. The average specific gravity of Tschermak and Goldschmidt is attached, and also their hardness:—

Species.	Composition.	Sp. Gr.	Hardness.
Albite	Ab_1,An_0 to Ab_8,An	2.62	6 – 6.5
Oligoclase	Ab_6,An_1 to Ab_2,An_1	2.64	6 – 7
Andesite	Ab_3,An_2 to Ab_4,An_3	2.65	5 – 6
Labradorite	Ab_1,An_1 to Ab_1,An_2	2.69	5 – 6
Bytownite	Ab_1,An_3 to Ab_1,An_6	2.71	.....
Anorthite	Ab_1,An_8 to Ab_0,An_1	2.75	6 – 6.5

It will be observed, that the specific gravity increases with the percentage of anorthite. By means of the specific gravity, owing to the great exactness, with which the density of a heavy solution can be regulated, this determination of the feldspars is very reliable, so long as the material is pure and fresh. The presence of foreign matter, or any alteration, will lessen this certainty; for instance, a kaolinization would lessen, while the development of carbonates, the formation of mica etc., must increase the specific gravity.

Members of this group are characterized by their brittleness, easy cleavage and glistening cleavage-face. Their structure is either compact cleavable, lamellar or granular. Their color is white, gray or reddish. All crystallize in the triclinic system.

Bournon, in 1802, described, as *indianite*, certain white, gray and reddish granular feldspars, which form a matrix for corundum, in the Carnatic. This was subsequently discovered to be anorthite. The associate feldspar with corundum at Chester, Mass., at Unionville, Pa., and at certain mines in North Carolina seems to be *oligoclase*. In Dr. Smith's paper, analyses of several feldspars, which have altered from corundum, show them to be oligoclase.

Zoisite.—This mineral has the following chemical formula:— $4CaO.3Al_2O_3.6SiO_2.H_2O$ = silica 39.7, alumina 33.7, lime 24.6, water 2.0=100. The alumina is sometimes replaced by iron, thus graduating toward epidote, which has the same general formula, but from which it was separated some years ago on crystallographic ground. The crystals are orthorhombic in symmetry, with prismatic type, deeply striated or furrowed vertically, and seldom distinctly terminated. Also massive, columnar to compact. It also occurs commonly in crystalline masses longitudinally furrowed.

Zoisite is brittle, with uneven fracture. The cleavage is very perfect parallel to the brachydome. Hardness, 6 to 6.5. On the cleavage face, the luster is pearly; otherwise it is vitreous. The color ranges from grayish-white, gray, yellowish-brown, greenish-gray to apple-green. A peach-blossom red and rose-red variety, is called *thulite*.

As an associate of corundum in the United States, it was de-

scribed under the name of *unionite* by Silliman, who found it at Unionville, Pa., in company with euphyllite. Fine specimens have been found at the Cullakenee Mine, N. C. Genth says of the latter, that many of the specimens show distinctly, that it is the result of the alteration of corundum. The pink corundum is often surrounded by a thin coating of white zoisite. Other specimens show corundum altering on the outside to zoisite, and on the interior to margarite.

In the corundum regions of Georgia, zoisite has been found only at Hog Creek mine, near Hiawassee, Towns county.

FIBROLITE.—This is a fibrous, firm and compact variety of sillimanite. It is sometimes radiated, and is grayish-white to pale brown and pale olive-green in color. It has been known for a long time, to accompany corundum in the Carnatic, in India, and near Canton, China. Interesting specimens of corundum, showing alteration into fibrolite, have been noticed from the Falls of the Yantic, near Norwich, Conn., from Burke county, N. C., from Laurens county, S. C., from Mineral Hill, Delaware county, Pa., and, lately, from several other places in North Carolina. When the alteration has just begun, the fibrolite appears as a very thin, vitreous incrustation. Specimens have been found in all stages, even to the complete disappearance of the corundum; in the latter instance, a fibrolite pseudomorph after corundum remains.

KYANITE.—The empirical formula of kyanite is uncertain. It is regarded by some as a basic orthosilicate, $Al_2O_3.SiO_2$, like andalusite and sillimanite, while by Groth it is considered a metasilicate, $(AlO)_2\ SiO_3$. It crystallizes in the triclinic system, and is usually found in long bladed crystals rarely terminated. The macropinacoids or flat blade faces are often striated horizontally. It also occurs coarsely bladed, columnar to subfibrous. Cleavage on the macropinacoids, very perfect. The hardness varies from 4 to 7.25 according to direction. Color, blue to white ; blue along center of blade with white margin. It also occurs gray, green and black.

It is often associated with corundum at Litchfield, Newton and Washington, Conn. It occurs in large roll masses with corundum and massive apatite. In North Carolina, it is found at several cor-

undum mines, associated with corundum and muscovite, which, according to Genth, is derived from the alteration of the corundum. In Georgia, as an associate of corundum, it is found near Powder Springs, Cobb county.

TOURMALINE.—Dr. Smith found tourmaline in great abundance with the emery of Naxos, and in less quantities in other localities, disseminated through the emery. In the United States, most interesting specimens have been collected.

Colonel C. W. Jencks found a pseudomorph of tourmaline after corundum at Corundum Hill, N. C. The length and breadth of the crystal is about two inches. It shows the planes of the hexagonal prisms and portions of one pyramidal plane. Almost the entire crystal has altered into black tourmaline, leaving only a shell one-fourth of an inch thick, while the lower part is mixed with corundum. Plates of green chlorite penetrate the crystal. From Unionville, Pa., Dr. Isaac Lea mentions a crystal of transparent green tourmaline passing through the middle of a prism of diaspore, the whole enveloped by lamellar crystals of pearly muscovite. The associate tourmaline of corundum is commonly black. The triangular prism predominating, it is readily distinguished from common black hornblende, which it resembles somewhat closely, by examining a cross-section of the crystal, which is either three, six or nine sided. It has a strong tendency toward crystallization; hence crystals, usually prismatic in habit and often slender to acicular, are very common. The prismatic faces are very strongly striated, vertically, often giving a rounded appearance to the crystals. The crystals frequently occur alone, but often in parallel and radiating groups. A columnar and black variety is often confused with common hornblende; but its lack of cleavage and its coal-like appearance on a broken surface aid in distinguishing it. Tourmaline is almost wanting in cleavage, and is brittle even to friable. The hardness is 7.5. Its chemical formula is uncertain. Tourmaline is a complex silicate of boron and aluminum, with either magnesium, iron or the alkali metals prominent. Tourmaline has been found in Georgia, at the Laurel Creek corundum mine, Rabun county, and at the Hog Creek corundum mine, near Hiawassee, Towns county.

STAUROLITE.—This mineral usually occurs in cruciform twins; and, on this account it has been much worn as an amulet. Just at this time, it is quite the fashion to carry small twin crystals of staurolite in the pocket, and call them "good luck stones." The crystals are orthorhombic; they have distinct, but interrupted, cleavage, parallel to the brachypinacoid; they are brittle, and have a subconchoidal fracture. In color, staurolite is dark reddish-brown to brownish-black; and in diaphaneity, it varies from translucent to nearly opaque. Its hardness is 7 to 7.5; and its specific gravity, from 3.65 to 3.75. The chemical formula is $HAl_5FeSi_2O_{13}$, in which the Aluminum is partly replaced by ferric iron, and the ferrous iron by magnesium and manganese. Genth analyzed a few minute massive brown grains of a mineral associated with damourite, and resulting from the alteration of corundum, at the Corundum Hill mine, Macon county, N. C., and found them to be staurolite. The specific gravity was 3.711.

HYDROUS SILICATES.

Micaceous Minerals.

The micaceous minerals, associated with corundum, will be considered in the following order, viz: —

1. Micas.
2. Clintonites.
3. Chlorites.
4. Vermiculites.

The *micas* include the micas proper, that is, those micaceous minerals, characterized by a highly perfect basal cleavage, yielding very thin, tough and more or less elastic laminæ. *Clintonites*, or the brittle micas, form a transition between micas and chlorites. They include those micaceous minerals, which are near the micas in cleavage, crystalline form and optical properties, but which differ from them physically, in the brittleness of the laminæ, and chemically, in their basic character. The *chlorites* include a large number of ferrous magnesium-aluminum silicates of micaceous character, but whose laminæ are tough and comparatively inelastic. They are usually green in color, and hence are called chlorites. The *vermiculites* form a supplementary group, being chiefly hydrated com-

pounds, resulting from the alteration of the micas. They are, in part, closely related to the chlorites; but they vary from the chlorites somewhat widely in composition.

All these species are characterized by their highly perfect basal cleavage; and they yield easily thin laminæ. They all crystallize in the monoclinic system, and imitate so closely hexagonal or rhombohedral symmetry, that it is only within the last few years, that their true symmetry has been recognized. They are more or less closely related in the angles of prominent faces. They are classed as hydrous silicates, but not strictly, since the water they yield upon ignition may be regarded, probably in all cases, as water of constitution.

MICAS.

Phlogopite, *Muscovite* (Damourite, Ephesite, Lesleyite), *Paragonite* (Euphyllite.)

PHLOGOPITE.—A magnesian mica, especially characteristic of serpentinous formations. The crystals are often large and coarse, usually only six-sided prisms, more or less tapering, with irregular sides. Cleavage, highly eminent; laminæ, tough and elastic. Hardness, 2.5 to 3; specific gravity, 2.78 to 2.85. Its color is yellowish-brown to brownish-red; also pale brownish-yellow, green, white and colorless. It is commonly present in chrysolite formations. Beautiful small crystals have been found in the Laurel Creek corundum mines, Rabun county; and, in 1889, large quantities of a heavy, foliated kind, intimately associated with a massive asparagus-green apatite, were taken from one of these mines. Analysis, in the laboratory of the U. S. Geological Survey, showed that this phlogopite had begun alteration to a vermiculite.

MUSCOVITE (Damourite).—Damourite, for a long time supposed to be a distinct species, was proved by Dr. Genth, six or eight years ago, to be muscovite. Under damourite, as a variety, are included, in the last edition of Dana's System of Mineralogy, margarodite, gilbertite, hydro-muscovite and most hydro-mica in general. The foliæ are less elastic than muscovite; the luster is somewhat pearly or silky; and they feel unctious like talc. The scales

are usually small; but it passes into forms, which are fine scaly or fibrous, as sericite, and finally into a compact crypto-crystalline form. It is often derived by alteration from kyanite, topaz and corundum.

Damourite is one of the most important alteration products of corundum. It may be formed, by direct alteration of corundum, or from some of its changed conditions. Besides this, it varies so in appearance, that surety of correct diagnosis necessitates a chemical analysis. The manifold nature of damourite is shown in the dissemination of the mineral as pseudomorphs after silicates. Dr. Genth notices pseudomorphs after corundum from Unionville, Chester county, Pa., from North Carolina, and from Laurens county, S. C.

Ephesite and Lesleyite.—Dr. J. Lawrence Smith[1] first noticed the former of these from Gumuch-dagh, and gave it the name *ephesite*, because of its occurrence near the ancient city of Ephesus. This is a mechanical mixture of corundum and damourite, or the result of an almost complete alteration of corundum into fibrolite and the subsequent alteration of the latter into damourite. Dr. Isaac Lea called a similar mixture from Unionville, Pa., lesleyite, not observing, that the material was a mixture of two minerals. This mineral substance, according to Dr. Smith, resembles white kyanite of lamellar structure. Dr. Genth describes lesleyite as fibrous and compact, fibrous-columnar, fibrous and divergent, with a grayish-white color to reddish, depending on the presence of iron. The hardness is given at from 4 to 7.

Paragonite.—This is a soda mica, corresponding to muscovite in composition. It commonly forms a mass of rock, containing kyanite, staurolite, garnet and tourmaline, called *paragonite schist*. Its association, in Saxony and elsewhere, with corundum, leads Genth to ask, if these paragonite schists may not be the result of the alteration of corundum passing through the stage of fibrolite and damourite.

Euphyllite.—This is a sodium-potassium mica, apparently intermediate between muscovite and paragonite, but more basic. It is a rare associate of corundum at Unionville, Pa.

[1] Amer. Jour. Sci. (II) 59, 1851. 48, p. 254, 1869.

CLINTONITES.

Margarite, Chloritoid.

MARGARITE.—Its name is derived from the Greek word for pearl. It is characterized by a pearly luster on a cleavage face. Its hardness is 3.5 to 4.5, and its specific gravity varies from 2.99 to 3.08. In color, it is grayish-white, pink or yellowish. It is commonly associated with corundum, and in many cases is obviously formed directly from it. Smith and Silliman discovered it, almost simultaneously, in Asia Minor and Greece, and in Pennsylvania and South Carolina respectively. Since then, it has been discovered in many corundum localities ; but, on account of certain forms of damourite, which resemble it closely, an analysis is necessary to prevent confusion. An analysis of this mineral from Gainesville will be found on page 99.

CHLORITOID.—Chloritoid has been found in many corundum localities. It was noticed by Smith to be in abundance with the emery of Gumuch-dagh, covering the surface of emery blocks, and sometimes entering largely into the substance of the emery. From this, it was very apparent to him, that it was formed by elimination from the mass of emery at the time of its consolidation.

The crystals are grouped in rosettes. When massive, which is its usual habit, the foliæ are coarse and often bent or curved, and brittle. Its hardness is 6.5, and its specific gravity, 3.52 to 3.57. In color it is dark-gray, greenish-gray, greenish-black and grayish-black.

CHLORITES.

Prochlorite, Corundophilite.

Strict lines of division between the chlorites is extremely difficult, and a correct interpretation of their composition is equally so, neither having, as yet, been satisfactorily accomplished. Chemically considered, the chlorites are silicates of aluminum, ferrous iron and magnesium, chemically combined with water. Chromium may be present in small amount, replacing a part of the aluminum, in which case, the color is pink instead of the common green. Ferric iron is also sometimes present, replacing a part of the alu-

minum. Calcium and the alkalies, characteristic of all true micas, may be present in small amounts; but they are usually conspicuous by their absence. The chlorites, which are about to be described, belong to a distinct series, showing a constant percentage of water, and a decrease of silica, magnesia and ferrous iron, accompanied by an increase in aluminum. Since, however, it is impossible to distinguish them, except by chemical analysis, the varieties, which have been found associated with corundum, will be considered together.

PROCHLORITE, CORUNDOPHILITE.—Externally, these two chlorites are indistinguishable. Both are monoclinic, and occur, either as six-sided tables or low prisms, or massive, foliated or granular. Both possess the same color, viz., green, grass-green, olive-green, blackish-green. In the case of prochlorite, the laminæ are simply flexible, while corundophilite laminæ are somewhat elastic.

Varieties of these, not too near the division line, will present certain optical differences. Chemical analysis, therefore, is absolutely necessary for a safe determination of these species. As has been said previously, an increase in alumina will show a decrease in silica, magnesia and ferrous iron. Corundophilite, therefore, can be distinguished from prochlorite, by its possessing more alumina and less silica, ferrous iron and magnesia. Prochlorite usually has a large amount of ferrous iron; but analyses of the prochlorite found associated with corundum at Corundum Hill, North Carolina, show only a small percentage.

THE VERMICULITES.

Jefferisite, Culsageeite, Kerrite, Lucasite, Painterite, Maconite, Dudleyite, Willcoxite.

The vermiculite group represents a large number of micaceous minerals, which, in the main, are alteration products of the micas. They are closely related to the chlorites; but they vary from them somewhat widely in composition. Many of them have a more or less indefinite chemical nature, varying with the degree of alteration of the original minerals. The laminæ may be said, in general, to be soft, pliable and inelastic; the luster is pearly or bronze-like,

according to color, which varies from white, through shades of yellow, to brown. Dried over sulphuric acid, or heated at from 100° to 110° C., they lose, up to ten per cent. of water; at 300°, more water is given off, and, at red heat, a somewhat large proportion is given off. This drying process leads to the common physical character of exfoliation, which is common to nearly, if not all, the vermiculites, causing them to expand, when heated, into worm-like threads. This physical change caused the name vermiculite to be given to the oldest member of the group, from the Latin, *vermiculari*, to breed worms.

Vermiculites are extremely common in corundum veins, in some instances forming the complete gangue for the mineral. This is instanced at the Corundum Hill mine, North Carolina, where Chatard[1] speaks of a so-called "sand-vein," made up of a vein-like mass of brown vermiculites, containing an abundance of small corundum crystals. Again, in his sections:—In section A, he finds a six-inch seam of vermiculites; in Section B, twelve inches of fine, scaly, brown vermiculite; and in section C, a six-inch streak of vermiculite. Vermiculites also play a prominent part in the corundum veins of the Laurel Creek mine, and certain other corundum localities of Georgia.

JEFFERISITE (Culsageeite.)—The culsageeite variety of jefferisite comes from Corundum Hill mine, near Cullasagee Post-office, N. C. It consists of broad crystalline plates, of eminent cleavage and pearly luster. The color is yellowish-brown to brownish-yellow. It shows very well the characteristic of exfoliation on heating. Here, it is formed from the alteration of a chlorite, which very frequently shows an incipient alteration to this mineral, by a discoloration to brown or brownish-yellow.

KERRITE.—Kerrite was named by Dr. Genth, in honor of the late Professor W. C. Kerr, State Geologist of North Carolina. It consists of innumerable fine scales, which, under the microscope, present no definite shape. Its color is pale greenish-yellow with a tint of brown, and its luster is pearly. It does not exfoliate as readily as jefferisite.

[1] Bul. 42, U. S. Geol. Survey, T. M. Chatard.

LUCASITE.—This mineral was found to be a new vermiculite species, by Dr. T. M. Chatard, who discovered and analyzed it. He named it for Dr. H. S. Lucas, who has been such an indefatigable worker, in developing the corundum deposits of Georgia and North Carolina. This vermiculite occurs with actinolite at Corundum Hill, N. C. The foliæ are small, compact and disseminated; and they exfoliate largely on ignition. It is easily decomposed by hydrochloric acid.

PAINTERITE.—This vermiculite occurs at the Corundum mine in Newlin township, Chester county, Penn., as a dull green mineral; and, as a golden-yellow mineral, it is found on the farm of James Painter, Middletown, Delaware county, Penn., for whom it was named. In the former color, it much resembles culsageeite, both outwardly and optically.

MACONITE.—This species discovered by Genth, closely resembles fine scaly jefferisite. The scales are harder than kerrite, and are irregular. It exfoliates largely upon heating, and fuses with difficulty to a brown glass. It is easily decomposed by hydrochloric acid, with a separation of silica in scales.

DUDLEYITE.—This vermiculite is an alteration product of margarite. It is found in large quantities at Dudleyville, Ala. Genth describes it, as a soft bronze or brownish-yellow mineral, which still retains the form and pearly luster of margarite. When heated, it exfoliates very slightly, and melts with difficulty into a brownish-yellow blebby mass. It decomposes easily in hydrochloric acid, with the separation of silica in pearly scales. This mineral is also found in the North Carolina corundum regions.

WILLCOXITE.—This was named by Genth for Colonel Joseph Willcox of Philadelphia, Penn., the well known amateur collector of American minerals and fossils. It occurs as a coating around a nucleus of corundum, and is presumed to be an alteration of it. It occurs at Shooting Creek and Cullakenee Mines, Clay county, N. C. The scales are white to greenish or grayish-white, with pearly lustre, resembling talc. Before the blow-pipe, in thin splinters, it fuses with difficulty into a white enamel, coloring the outer flame yellow. It decomposes with difficulty in hydrochloric acid, with the separation of silica in pearly scales.

THE SERPENTINE AND TALC GROUP.

Serpentine, Genthite, Talc.

This group, containing serpentine and talc, as the leading members, is closely related to the chlorite group. Included with them are some amorphous, magnesian silicates, such as genthite.

SERPENTINE.—Serpentine crystallizes in the monoclinic system. Its composition is that of a hydrous magnesian silicate. Crystals of serpentine are sometimes found in the chrysolite rocks, but only as pseudomorphs after chrysolite. It is usually massive, and occurs in these chrysolite rocks as an alteration product. It also occurs delicately fibrous and silky, in which form it is extensively used for asbestus. The color is from yellowish-green to blackish-green, and sometimes red and black. Massive serpentine, more or less pure, frequently occurs as an alteration of chrysolite or pyroxene; but it has not been observed in connection with the corundum-bearing magnesian formation of Georgia. The chrysolite rocks of these formations are frequently spoken of as serpentine, because of their partial serpentinization; but this is a misnomer.

GENTHITE.—This amorphous mineral occurs as an apple-green or a yellowish incrustation on chromite near the Hog Creek mine, Hiawassee, Towns County. It is a hydrous nickel-magnesium silicate, with the formula $2NiO.2MgO.3SiO_2.6H_2O$ = silica 34.8, nickel protoxide 28.8, magnesia 15.3, water 20.9=100. In a closed tube, submitted to heat, it blackens and gives off water; it is infusible before the blow-pipe. When exposed to the air for some time, it loses its apple-green color and breaks down into a powder.

TALC.—Talc is either orthorhombic or monoclinic; it usually occurs in foliated masses, or granular massive; it is also fibrous or compact. When foliated, the foliæ are easily separated; it is soft, and has a greasy feel. The foliated variety is known as *talc*. The fine granular and compact varieties are known as *soapstone* or *steatite;* the very coarse, as pot-stone, because used by the Indians and aborigines of this country for making pots. The fibrous

varieties are usually pseudomorphs after pyroxene. All these varieties occur in chrysolite formations, and are readily distinguished by their softness and greasy feel.

PHOSPHATES.

Apatite, Lazulite.

APATITE.—Apatite is a calcium phosphate, in which either fluorine or chlorine, or both together, are combined with part of the calcium. It crystallizes in the hexagonal system, and has pyramidal hemihedrism. Crystals vary from long to short prisms; they also occur as low pyramids, slightly modified by prismatic faces. The hardness of apatite is from 4.5 to 5, and its specific gravity is from 3.17 to 3.23. Its cleavage is imperfect, and its fracture uneven. It is brittle. Its luster is vitreous, inclining to sub-resinous, and in color it is usually sea-green to bluish-green, though it sometimes occurs white (opaque and transparent), pink, purple, brown and black.

Two pieces of apatite crystals, one four inches, the other two inches in diameter, were given to the Survey, as specimens from the Laurel Creek mine. They are sea-green in color and transparent to translucent. Scales of phlogopite are inclosed by the large piece, and it encases parts of both specimens. This is a rare associate of corundum, and is not mentioned among the minerals of the North Carolina corundum mines.

LAZULITE.—This is essentially an aluminum phosphate, in which are present, in varying proportions, magnesia and iron protoxide, with water. It crystallizes in the monoclinic system; the crystals are usually acute, and sometimes flattened. It also occurs massive, granular to compact. Its cleavage is indistinct, and its fracture uneven. Its hardness is from 5 to 6, and its specific gravity is 3.05. In color, it is azure-blue. It occurs in abundance with corundum at Crowder's Mountain, Gaston county, N. C. It is not known in Georgia in this association; but beautiful sky-blue crystals, over an inch broad and as long, are found at Graves' Mountain in Lincoln county.

CHAPTER IV.

GEOLOGY OF THE CRYSTALLINE BELT.

INTRODUCTION.

Introductory to the descriptive chapter on the corundum deposits of Georgia, a brief chapter on the geology of the entire so-called crystalline area will not be amiss. The mineral resources of any region are so dependent upon its geology, that an intelligent view of any one of them requires a general knowledge of the age, structure, lithology and topography of the region, in which it is found. Such are their reciprocal relations, that knowledge of one adds to our knowledge of the other. Likewise the liability of error in conclusion, in regard to any one subject, decreases in proportion to the increase of acquaintance with all.

Notwithstanding the importance of detailed geological information, the crystalline belt has received only the most cursory examination. Mapping in detail has been held in abeyance for general prospecting. Attention has been confined to the discovery of economic minerals, to the almost complete exclusion of those things which would have lent acumen to the search. Hence, many facts are wanting for a perfectly satisfactory discussion of the geology of this area. Still, a few general statements in regard to the same may be found useful.

MAP OF GEORGIA.

The last geological map of the entire State was compiled by the Agricultural Department in 1885, and may be seen in the report of that year. Their data was altogether insufficient for a good map; yet, in a rough way, it shows the prominent formations and their distribution over the State.

Spencer, in his "First Report of Progress, 1890–91," maps in detail the area south of a line drawn from Columbus to Knoxville, and west of Flint river. His last report, "Geology of the Paleozoic Group of Georgia and Resources, 1893," contains a detail map of ten of the northwest counties, or the entire northwest corner of the State.

Fig. 4.

Geological Outline Map of Georgia.

A, Algonkian; S, Semi-crystalline; P, Paleozoic; M, Mesozoic; C, Cenozoic; R, Recent.

From these maps, it may be learned that more than one-half of the surface area of Georgia is covered by the later formations. This area lies south of a line drawn south of west from Augusta, Richmond county, to Columbus, Muscogee county, and is made up of Mesozoic, Cenozoic and recent formations.

The known Paleozoic area of Georgia covers about 3,408 square miles. In it are represented all the systems of the Paleozoic, viz.:—Cambrian, Silurian, Devonian and Carboniferous. The Devonian, Spencer does not map, because the formation is extremely limited, and occurs in valleys; consequently outcroppings are rarely seen. A line drawn south from a point a few miles east of Cohutta Springs, Murray county, to Cartersville, Bartow county, and then south of west to Esom Hill, Polk county, inclosing the northwest corner of the State, sharply defines the limits of the Paleozoic in Georgia. This is known as the "Cartersville Fault."

Between these two areas of the State, and occupying the greater part of North Georgia, is the so-called "Crystalline Belt," with a surface area of about 12,430 square miles. It will be seen, by referring to Fig. 4, that this region is divided into a "semi-crystalline" and a "holo-crystalline" area. Explanation of this division will be found in a following section of this chapter.[1] The line is simply provisional, and makes no attempt at accuracy, leaving that to future mapping. The north and south line, however, separates the two areas fairly well. Less is known of the east and west line.

TOPOGRAPHY OF THE CRYSTALLINE BELT.

The surface of the earth presents a figuration and transfiguration due to natural processes, and "now stands in a transient stage between its past and its future." All these changes have been brought about by two forces, the one *constructive*, the other *destructive*.

The topography of the Crystalline Belt represents the action of these two forces. Great crust movements raised the Appalachian system, of which this belt is a part; these were *constructive*. During these periods of uplifting, atmospheric and aqueous agencies

[1] Structure and Physiography of the Crystalline Belt and its Evolution.

were acting, and have continued to act. These *destructive* forces have sculptured the belt into its present features.

The Crystalline Belt, on account of its crystalline rocks and complex structure, presents a more or less diversified topography. The southern portion of the belt is broken by low, undulating hills, intensified along the large rivers. These elevations increase, as we go north. Then come the foot-hills of the Blue Ridge, culminating in the Blue Ridge itself, peaks of which, in Georgia, range from 3,000 to 4,000 feet above the sea-level, the maximum height being 4,790 feet. This is the highest point in Georgia—Mount Enotah on the southwestern side of Towns county.

The drainage is that, common to all mountainous districts and areas approaching sea-level, or "base level," as it is technically called. The streams present all stages of activity from youth to old age. Tributaries of the Tennessee river drain the belt on the north; the south is drained by the Savannah, Ogeechee, Oconee, Ocmulgee, Flint and Chattahoochee rivers.

Before leaving this subject, an individual topographical feature, showing the wonderful erosive power of a river, is worthy of mention—the Tallulah Gorge in the southern part of Rabun county. Its superb grandeur, people have traveled far to see; as a geological feature, its fame is world-wide. This narrow gorge is several miles long, and nearly a thousand feet deep.

STRUCTURE AND PHYSIOGRAPHY OF THE CRYSTALLINE BELT, AND ITS EVOLUTION.

In the consideration of the structure of the Crystalline Belt, with a view of interpreting the same, it will be necessary to review briefly the structure of Northwest Georgia. North and west of the Crystalline Belt, and occupying the entire northwest corner of Georgia, all the systems of the Paleozoic are represented. Erosion, which has been actively at work, since the uplifting of the Appalachian system, following the Coal epoch, has removed thousands of feet of the various formations, and sculptured the area into its present landscape. The general structure of the region, however, is mainly consequent upon the faults, overthrows and folding pro-

duced by orographic movements. The Paleozoic ceases abruptly, on contact with the Crystalline Belt. A gigantic physical break or unconformity, which C.W. Hayes has aptly termed "The Cartersville Fault,"[1] marks a distinct separation of two regions. The structure of the Paleozoic area has been studied in a most careful manner by Hayes, Campbell and Spencer, and full particulars may be found in Spencer's report on this region, and in the reports and atlas sheets of the U. S. Geological Survey, by Dr. C. W. Hayes. The structure of the Crystalline Belt has only been studied superficially, and sufficient scientific examination has not been made to warrant more than hypothetical conclusions. In working out the detail geology of the Paleozoic, the geologists were in a field much less disturbed by dynamic forces, and therefore still containing abundant paleontological evidence. In the Crystalline Belt, no positive[2] fossil remains have been found, and the rocks are much more disturbed and altered. The rocks of the Crystalline Belt are divisible into two petrographical classes. The first class consists of a series of slate, shale, schist, conglomerate and marble, which, through metamorphism, have become more or less crystalline. These undoubtedly are all clastics, and despite their metamorphosed condition, preserve, in a measure, evidences of their origin; therefore they are classified as *semi-crystalline.* The second class includes a series of granitic, gneissic and schistic rocks, which are thoroughly crystalline and without any determinable traces of their origin. The latter, therefore, are classified as *holo-crystalline.*

The main body of the semi-crystalline rocks of the Crystalline Belt is confined to a region bordering on the Paleozoic. Its northwestern limit is the Cartersville Fault; its southeastern, the beginning of the "holo-crystalline" rocks. In the small map on p. 59, a temporary divisional line has been drawn between these two areas.

[1] C. W. Hayes; Bul. Geol. Soc. Amer., vol. II., p. 147, 1890.

[2] It will be of interest to note the possible fossil, discovered in the marble belt by Mr. S. W. McCallie, Asst. State Geologist of Georgia. The specimen was sent to Prof. C. D. Walcott, Director of the U. S. Geological Survey, who returned it, saying that he was not certain of its character, but thought it might be the fossiliferous remains of a gasteropod.

It is suggestive, rather than an attempt at accuracy; much more work will be required in this section, on account of the nature of the transition between them, before the latter can be hoped for; nevertheless, for present purposes, it is fairly accurate. Included in the semi-crystalline area are patches of intrusives, whose structural relations to the inclosing clastics have an important bearing on the evolution of the Crystalline Belt.

It is noteworthy that throughout the semi-crystalline area, wherever an intrusive occurs, the contact clastics show indubitable evidences of metamorphism. A single instance will be cited, because of its interesting nature and its proximity to the holo-crystalline rocks. Near the Tate marble quarries, Pickens county, McCallie[1] observed that apophyses run out from an eruptive basic mass close by, and overlap the marble at several points. The accompanying plate[2] shows one of these veins, intruded between gneiss and marble. The result of this contact was evidently the conversion of a clastic into a gneiss, and important physical changes in the marble, the most interesting and noticeable of which was the expulsion of the coloring matter, so common in Georgia marble. McCallie found that this was true of every similar occurrence.

Principally, the rocks of the semi-crystalline area are mica-schists, usually soft, and bedded slates. All dip to the southeast, and strike about 20 degrees west of south. The dip ranges from 15° to 60°, with an average dip of about 30°.

To the southeast of the semi-crystalline area, and transitional with its formation, lie the holo-crystalline rocks. Gneiss is the prevailing type. Interstratified with the gneiss, in certain portions of this area, a few beds of semi-crystalline rocks have been observed, such as the belt of limestone running through Habersham and Hall counties, the quartzite of Tallulah Gorge, and the phyllites of Lumpkin county. Breaking through the holo-crystalline rocks, a belt of outcroppings of basic magnesian silicates, containing the corundum of Georgia, extends from North Carolina through Geor-

[1] See Bulletin No. 1, Geological Survey of Georgia; The Marbles of Georgia, by S. W. McCallie, p. 40.

[2] See Plate II.

gia into Alabama. These eruptive masses are most numerous west of the Chattahoochee river, close up to the "semi-crystalline" line. Although some are found east of the river, as far as Monroe, Walton county, *none* occur in the semi-crystalline area. These physiological facts are significant in the study of the evolution of the Crystalline Belt. The presence of clastics among holo-crystalline rocks tends to confuse the opinion, that this area represents the fundamental complex. The disappearance of these corundum-bearing formations points to a time of deposition of the semi-crystalline rocks, later than these intrusions, while their continuity along a definite belt is suggestive of the force and direction of the great earth movement, that developed this line of weakness and permitted the welling up of so much igneous matter.

The strike of the holo-crystalline area corresponds with that of the semi-crystalline; but the dip is on an average much steeper and may be given as about 50°. Moreover, disturbances and alterations are more extensive in this region, than in the semi-crystalline. The sharp folds and faults, which must exist in such a folded area, are no longer noticeable. Rocks have changed their physical character; for instance, diorite has taken on a gneissoid structure; slates have changed into phyllites (mica-slates), and the mica-schists are harder than those of the semi-crystalline area. Even local metamorphism, consequent upon igneous intrusions, so noticeable in the semi-crystalline rocks, is little, if at all, apparent in the holo-crystalline rocks.

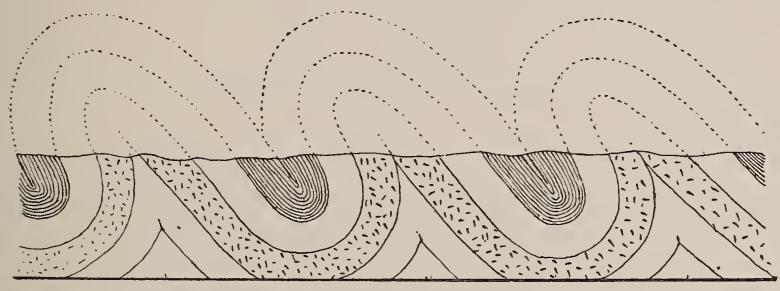
The apparent constancy of dip to the southeast throughout the whole Crystalline Belt is one of the most interesting structural features of the region. It shows, almost conclusively, that the entire area has been affected by a great orographic movement, the objective point of whose force was to the northwest, or at right angles to the present strike of the rocks. There can be little doubt, also, from the structural and physiological features of the Crystalline Belt, but that the force exerted its influence over a long period of time. The complex structure thus produced, erosion has effaced into a deceitful simplicity, that will always be a source of trouble to the economic worker. He must guard against taking, as the real

HORNBLENDE APOPHYSIS OVER MARBLE, NEAR TATE, PICKENS COUNTY, GEORGIA.

thickness of a formation, the measurement of its horizontal extent; for what appears as one bed, now that general erosion has removed the original surface, is in reality often a succession of beds. The complexity, moreover, is increased by metamorphism and superficial decay, which have wiped out, in a great measure, structural lines and similar evidences pointing toward sequence relations.

These facts are brought out in the following figure : —

Fig. 5.



Ideal geological section, showing the degradation of the tops of folds, and the direction of the force producing them.

This figure serves, also, to illustrate the method of determining the direction of force in simple earth movements. The longer slope of the fold is always toward the moving force; and, after erosion has removed the tops of the folds, only the longer slope remains, as the dip of the strata.

The structural features, which have been noted, may then be briefly summarized as follows : —

1. The "Cartersville Fault," which marks a time interval between the deposition of the semi-crystalline rocks of the Crystalline Belt and the Oostanaula Shales of the Paleozoic.

2. The apparent perfect transition between the semi-crystalline and the holo-crystalline rocks.

3. The absence, in the semi-crystalline area, of the magnesium-corundum deposition, which characterizes the holo-crystalline area.

4. The constancy of strike and dip of the rocks of the semi-crystalline and holo-crystalline areas.

5. The difference in degree of dip between the rocks of the semi-crystalline and holo-crystalline areas.

6. The absence of regional metamorphism in the eruptive portions of the holo-crystalline area, and its presence in the semi-crystalline.

7. The evidence, which testifies to an earth movement, preceding, and a continuous earth movement, following the deposition of the rocks of the semi-crystalline area.

From these observations on the structure of the Crystalline Belt, three hypotheses present themselves, viz.: —

1. That the semi-crystalline area is of the same age as the contact member of the Paleozoic, and that the holo-crystalline area is Archæan.

2. That the Crystalline Belt is older, than the contact member of the Paleozoic; that the divisions of the belt are of the same age; and that the holo-crystalline has the appearance of greater age, because of extreme metamorphism, brought about by igneous injections and concentrated dynamic forces.

3. That the semi-crystalline area is older than any member of the Paleozoic known in Georgia; that the corundum-bearing magnesian eruptives, were intruded prior to the deposition of the rocks of the semi-crystalline area; and that the holo-crystalline rocks formed a sea-floor for the deposition of the semi-crystalline.

The first two hypotheses do not conform to facts; but they are given, because they seem current.

The first hypothesis presumes to give an age to both areas; these ages, however, are at variance with the facts. The first fails to appreciate the Cartersville Fault, which represents an unmistakable time interval, because no cause could probably alter one part of an original series more than another, and produce such a great unconformity. The semi-crystalline area is evidently older than the Oostanaula shales. Again, in ascribing Archæan age to the holo-crystalline, present terminology[1] is undoubtedly violated.

The second hypothesis notices the time-break represented by the Cartersville Fault; but it does not permit of any interval between

[1] See Age of Crystalline Belt, p. 67.

the formation of the semi-crystalline and the holo-crystalline areas. It accounts for the difference of rock-character, by metamorphism, brought about by eruptives and dynamic forces. The seemingly perfect transition between the two areas tends to support the validity of this hypothesis. Opposed to it, however, is the disappearance of the corundum depositories at the semi-crystalline line; also, that lateral pressure from one direction, as shown by the strike and dip of the rocks, could have been sufficiently concentrated in one of the contiguous areas, to have removed evidences of contact metamorphism in one area and not in the other, especially at points close to each other.

Finally we are reduced to the third hypothesis, which presents conclusions more in accord with known facts, and may be held provisionally, until modified by later investigations. This views the Crystalline Belt as two distinct areas in point of age, and older than any other formations in Georgia. It considers the waters of the semi-crystalline sea to have washed the shores of a holo-crystalline continent already impregnated by the magnesian eruptives, in which we find deposits of corundum; and, further, that, at the time of the final uplifting of the semi-crystalline area, its formations, resting on the holo-crystalline sea-floor, which was being crushed and raised by the great orographic movement, were reacted upon, and the present sharp folding and faulting of the semi-crystalline area resulted.

AGE OF THE CRYSTALLINE BELT.

A conjectural age is still given to the rocks of this belt. Dr. Little,[1] State Geologist of Georgia, from 1874 to 1879, considered the whole area metamorphosed Lower Silurian. Dr. Spencer, in his last report,[2] maps the rocks of the Crystalline Belt, in contact with the Oostanaula shale of the Paleozoic, as metamorphic, and refers to them as questionably Lower Cambrian. The remainder of the belt he calls Archæan. Campbell and Ruffner[3] considered

[1] George Little, Report of Ga. Geol. Sur., 1876.

[2] J. W. Spencer, Geol. Paleozoic Group of Ga., 1893.

[3] A Physical Survey, extending from Atlanta, Georgia, across Alabama and Mississippi to the Mississippi River, along the line of the Georgia Pacific Railway, by J. L. Campbell and W. H. Ruffner, New York, 1883, p. 147.

the portion examined by them as Archæan, and distinguished the two divisions, Laurentian and Huronian. Since, however, no particular scientific examination of the area was made by any of these workers, except in detached areas, their statements may be taken as simply expressions of opinion, and not verified conclusions.

On the eastern slope of the Appalachian System, undoubted patches of Archæan rocks extend as far south as Virginia, and our geologies generally run them into Georgia.

With such data, the geological map of Georgia was compiled by the Agricultural Department in 1885; and thus the entire Crystalline Belt appears on the "legend" as Archæan. This, therefore, does not accord with any opinion, thus far expressed.

The prevailing opinion seems to be, that the Crystalline Belt is composed of rocks of at least two ages. The preceding section of this chapter coincides with this view. All the geologists, who have worked in the neighborhood of the Cartersville Fault, agree, that the rocks of the Crystalline Belt in that vicinity are metamorphosed clastics; and, if we may go so far as to infer it from their writings, they consider them of the Lower Cambrian. Until, however, more evidence is obtained to substantiate this age, which is probably correct, they may more properly be assigned to another period.

The greater portion of the Crystalline Belt, or what is here termed the *holo-crystalline area*, has been considered Archæan.

What rocks may be called Archæan?

Professor Van Hise, authority on Pre-Cambrian geology, in his exhaustive correlation bulletin, gives the following answer:[1]—"The Archæan is the basal complex of America. It has everywhere, if large areas are considered, an essential likeness. It consists mainly of granitic, gneissic and schistic rocks, among which are never found beds of quartzite, limestone or other indubitable clastics." He further adds, that their structural relations and the character of the rocks themselves show, that they have passed through repeated powerful dynamic movements.

[1] C. R. Van Hise, Correlation Papers—Archæan and Algonkian. Bul. U. S. G. S. No. 86, p. 13.

In the holo-crystalline area of the Crystalline Belt, are found, as cited [1] in the preceding section of this chapter, what Professor Van Hise would consider "indubitable clastics." If Professor Van Hise's definition of Archæan is accepted, the presence of such rocks in this area renders the assignment of Archæan age out of the question; and, if not, it at least makes this term objectionable, until better defined.

What age, therefore, can we properly assign to these two areas of the Crystalline Belt?

Rocks, heretofore, which, on account of their apparent clastic nature, could not be called Archæan, have been classified as Pre-Cambrian. American geologists now embrace the Pre-Cambrian clastics and their crystalline equivalents, under *Algonkian.* The Algonkian is limited, below, by the Archæan, and above, by the Cambrian. Sharp lines of demarcation are frequently impossible. Age has a tendency toward greater changes; nevertheless, removed regions of the same age may be unequally affected. In several areas, unconformities or structural breaks can be readily determined, while, in others, these distinct lines between the series will have been entirely wiped away, by metamorphosing influences. In this difficulty of differentiation, however, the Algonkian system is in no way different from other systems. In this period, we find time breaks, as in the others.

For these reasons, therefore, as an expression of our present knowledge, this entire complex Crystalline Belt may be provisionally assigned to the Algonkian period. Thus assigned, we are no longer involved in the absurdity of including known clastics in the Archæan; neither, if we have overlapped the Archæan or the Cambrian, have we done violence to our terminology.

[1] See pages 63 and 64.

GEORGIA FORMATIONS.

ORDER.	SYSTEM.	SERIES.	FORMATION.	HAYES' EQUIVALENT.
I.	Pleistocene.	Columbia.	Columbia.	
II.	Neocene.	Lafayette. ?	Lafayette.	
III.	Eocene.	White Limestone (Upper Eocene). Claiborne, Buhrstone } (Middle Eocene). Lignitic (Lower Eocene).		
IV.	Cretaceous.	Ripley. Rotten Limestone (?). Eutaw. Tuscaloosa.		
V.	Jura-trias.	?		
VI.	Carboniferous.	Coal Measures.	Coal Measures.	Walden Sandstone. Lookout Sandstone.
		Lower or Sub-carboniferous.	Mountain Limestone. Floyd Shales. Fort Payne Chert.	Bangor Limestone. Floyd Shales. Fort Payne Chert.
VII.	Devonian.		Chattanooga Black Shale.	Chattanooga Black Shale.
VIII.	Silurian.	Clinton.	Red Mountain.	Rockwood.
		Hudson. Trenton. Chazy.	Chickamauga (including Rockmart Slate).	Chickamauga Limestone.
		Calciferous.	Knox Dolomite.	Knox Dolomite.
IX.	Cambrian.	Potsdam (Upper Cambrian). Acadian (Middle Cambrian).	Oostanaula Shales.	Conesauga Shales. Rome Sandstone.
X.	Algonkian.	Georgia.	Semi-Crystalline. Holo-Crystalline.	Metamorphic.

GEOLOGY OF THE HOLO-CRYSTALLINE AREA.

The various rock formations, composing the Holo-Crystalline area, cross Georgia from the southwestern corner of North Carolina and the northwest side of South Carolina, and pass into Alabama about midway of the Georgia boundary, moving in a general southwest direction. Their course is practically straight, the strike being on an average 35° west of south. The dip is sometimes vertical; but generally it is sharply inclined to the southeast. In a measure, the structural features of the area conform to those of the Appalachian system; but the effacement of structural lines in many instances, their complexity, and extreme metamorphosed condition strengthens the opinion, that they have been subjected to late disturbances.

The rocks, thus far observed as making up the formations of the Holo-Crystalline Area, may be divided into eight distinct types. Three of these types, limestone, quartzite and slate, are indubitable clastics. Three of them are completely crystalline, namely, granite, gneiss and schist, and therefore exhibit no trace of clastic origin. Two are presumably of eruptive origin, and may be designated, according to their chemical and mineralogical composition, as peridotite and metamorphosed diorite or hornblende-gneiss.

The age of these rocks has been discussed in the preceding section of this chapter, and they have been assigned provisionally to the Algonkian. As was intimated, however, it is not impossible, that more thorough examination of this area will result in assigning a portion of it to the Archæan.

The prevailing rocks are gneiss and mica-schist. The mapping of these will require careful work, because of their alternating nature and easy transition from one to the other. The true bedding of these rocks has been more or less obliterated, and the existing structure is probably due to secondary foliation.

The youngest of these Algonkian crystallines are the eruptive. The peridotite type, which here includes the chrysolite and its alterations, steatite (soapstone), chlorite etc., is quite abundant in certain portions of this area.

These basic magnesian silicates sometimes occur in large masses; but they are usually found in Georgia, occupying small areas. Frequently, as elliptical-formed bodies, they stretch out several miles across the State, like a string of beads, with here and there a missing member. These are the formations, that are prospected for corundum.

It remains finally to speak of the intrusive (?) diorite or gneissoid hornblende. This type has been classified in this section as an eruptive; but sufficient proof has not been obtained to make it more than a probable assertion. It consists frequently simply of hornblende, usually with garnets; often it is feldspathic. The formations, if intrusive, are narrow *dykes*, stretching for miles across the country, and conforming to its general structure. Since their intrusion, they have been squeezed and folded, until now they present the characteristic gneissic structure. The breaking down of these dykes, consequent upon erosion, has spread the rotted material far beyond its boundaries, and hence gives rise to many of the so-called "red lands" of certain sections.

CHAPTER V.

DISTRIBUTION OF CORUNDUM IN GEORGIA.

POSITION OF THE CORUNDUM-BEARING FORMATIONS.

The corundum deposits of Georgia are *thought of*, as lying within a narrow belt, whose width, as it enters Georgia from North Carolina, is limited to the region between the Laurel Creek corundum mine, Rabun county, and Brasstown Creek valley, Towns county. This represents a distance, east and west, of about forty miles. The belt is supposed to narrow down, and enter Alabama from Troup county.

The finding of corundum in North Carolina, Georgia and Alabama, about the same time, led those, who understood the trend of the rock formation of this region, to the natural conclusion, that there must be a continuous belt of corundum deposits extending through the State. Prospectors in Georgia, therefore, scarcely stepped out of this belt in their search. Their efforts, however, south of the mountains, were spasmodic, the depth of superficial disintegration making work difficult and unsatisfactory. In the mountainous counties, Towns, Rabun and Habersham, where the barrier to easy prospecting is at a minimum, the prospectors have confined the greater portion of their work. The boundaries of this zone have therefore been more or less mythical, especially south of the mountains.

With this knowledge to begin with, time not permitting of much detail work, the field season was spent in the so-called "corundum belt" and the adjoining territory, covering an area of 4,000 square

miles. Results of the work show, that the corundum zone has been too narrowly limited, and that it is by no means confined entirely to the mountainous district.

GEOLOGICAL RELATIONS OF THE CORUNDUM-BEARING FORMATIONS.

All the corundum deposits, thus far observed in Georgia, occur in basic magnesian rocks, whose type has been given as peridotite, including chrysolite, anthophyllite, serpentinized chrysolites,[1] schistose chlorite and steatite or soapstone. These form igneous intrusions along the stratification lines of the holo-crystalline rocks, the gneiss and schist showing by existing characteristics, that they were distended prior to the final folding of this region, and probably at a time, when the beds of these crystalline rocks were made a portion of the continent. The great earth movement, that uplifted the area, developed lines of weakness and cracks. These wounds nature healed, by an injection of igneous matter. A portion of the rents, thus produced and healed, now form the basic magnesian silicates, in which the corundum deposits occur. Earth movements, since, have concealed, in a great measure, the metamorphic influences of this molten material, and have likewise folded some of the peridotite alterations into corresponding relations with the schist and gneiss.

A matter of note is the constant presence of hornblende-gneiss, either on one side or the other of these formations. Such being the case, and since these gneissic-hornblende formations, varying from fifty to three hundred feet and more in width, are continuous for miles across the country, they act as an excellent guide in a search for the corundum-bearing formations. Gneiss or mica-schist seems always to surround the peridotites, or "chrysolite formations," as they are commonly called, the hornblende-gneiss[2] apparently never coming in close contact with the peridotites.

[1] A perfect serpentine has not been seen in any of the corundum formations of Georgia.

[2] See map of Laurel Creek mine, page 79.

CORUNDUM VEINS.

The Georgia corundum occurs in veins intersecting the peridotites and their alterations. Sometimes it occurs in the contact bodies, that is, in the gneiss, mica-schist or hornblende-gneiss; such an occurrence, however, has not been observed in Georgia. The veins vary in form, from those having practically parallel walls (usually inclined and descending to unknown depths) to simply lenticular pockets. In width, they have been found from one to twelve feet.

The matrix of these veins differs, not only in different, but in the same, localities. These four types have been noticed, viz:—

1. Lime-soda feldspar, with quartz and phlogopite; also with vermiculites, instead of phlogopite.

2. Lime-soda feldspar, with actinolite.

3. A course-grained aggregate of lime-soda feldspar and a black hornblende. Margarite is sometimes present in place of the feldspar.

4. A massive vein made up of a light grass-green amphibole (smaragdite), lime-soda feldspar and a little chromite.

All these types have their walls of compact, scaly chlorite, which quite frequently contain corundum. The first type is the most common; and, scattered through it, or, as is usual in the case of small corundum, in "bunches" or "pockets," occur the various colored varieties of corundum. In such veins, also, immense specimens of massive corundum are found.

The second type is apparently rare. In this, only small, irregular pieces of corundum have been found, and these usually possess an outer zone of some alteration (?) product of the corundum, usually margarite.

The third type is more common than the second; but it differs from the first two in its massive, pegmatitic character, and in its hardness. The feldspar and hornblende are both apparently little altered, and are about equally proportionate. Gray, grayish-blue, and slightly pink corundum are evenly distributed through the mass in irregular grains, varying from the size of a pea to several inches in diameter. Margarite has been observed in such veins, largely developed.

The fourth type is very rare. It is known only at one property in Georgia, and only at a few localities in North Carolina. The rock is made up of fine blades of smaragdite, of a beautiful light grass-green shade, feldspar, and small grains of pink and ruby-red corundum, profusely scattered through the mass. In Clay county, N. C., beautiful pink corundum occurs in the smaragdite, as veins, from a half inch to two and a half inches in thickness, sometimes with a slight coating of the lime-soda feldspar. On account of their beauty, these are highly prized as mineral specimens, the contrast of the ruby-red and the brilliant green being decidedly striking.

VARIETIES OF CORUNDUM FOUND IN GEORGIA.

All the varieties of corundum have been found in Georgia, with the single exception of emery. The principal is the variety, corundum, the non-transparent material of the corundum species. A few gems of the variety, sapphire, have been found at Hog Creek, near Hiawassee, Towns county. These were small, prismatic crystals of ruby color, but somewhat cloudy. A few gems of sapphire are said to have been found at the Laurel Creek mine in Rabun county; this report, however, is not authentic.

The corundum of Georgia is usually pink, gray or blue, these colors frequently occurring in the same specimen. Shades of red and light to dark-blue are common. White corundum is rare, and shades of yellow and brown have not been observed.

Georgia corundum is not uncommonly found in crystals; generally in six-sided prisms, and usually without terminations, though sometimes they are terminated by pyramidal faces. More highly modified forms have been found at the Laurel Creek mine. In the main, however, it occurs in small grains or blocks. Massive pieces, weighing several hundred pounds, have been taken from the Laurel Creek mine frequently, and much larger pieces are occasionally found.

DESCRIPTION OF LOCALITIES.

RABUN COUNTY.

General Observations.—The corundum properties found in Rabun county, up to the present time, are located in the extreme

eastern and north central parts of the county. Only one has been worked for corundum—the Laurel Creek mine; but this is famous throughout the country. Others have been worked for asbestus, and most all of them, on which corundum is known to occur, have received more or less attention.

The county is extremely rugged, being broken up by steep hills and high mountains; but some of the innumerable valleys are unsurpassed by any agricultural lands in North Georgia, for richness of soil and productiveness. Moreover, access to any portion of this most northeastern county is comparatively easy.

THE LAUREL CREEK MINE.

Corundum was first discovered on Laurel Creek, in the early seventies by an Englishman, named Thompson. Colonel Jencks followed this discovery by examination, and worked intermittently during 1873 and 1874. Altogether, only a few month's work was put in, and the "find" seemed so poor, that the property was finally abandoned. In 1880, several men, living in the neighborhood, mined it for asbestus. Their mining was much hampered, by the frequent occurrence of hard and heavy rocks, which they were forced to remove. The nature of these rocks was unknown to them; consequently they dumped them to one side. *This dump was Corundum.* Dr. H. S. Lucas of Chester, Mass., who, already had been, for some time, actively engaged in corundum prospecting through North Carolina, hearing of these works, visited the locality, and at once purchased the property for the Hampden Emery Co. of Mass., which, for some years, practically controlled the corundum industry of the United States.

Under the able management of Dr. Lucas, corundum veins were exposed, a plant was established, and what had formerly been a poor asbestus mine, soon became one of the main sources of supply to the corundum trade of this country. Work was continued from 1880 to 1892 with eminent success. In the latter year, the hillside, under which they were working the most paying vein, caved in, and for a time work was paralyzed. At this time, they had reached a depth of 130 feet, and were working in a vein averaging 8 feet in width. Up to the summer of 1893, work was carried on

unsuccessfully at other points, the owners report, while a shaft was being run down through the debris to the main vein. In September of the same year, the mines were closed down, pending the financial stress.

To this brief historical resumé, a few words may be well added, in regard to the advantages, which have accrued to the country, from this single industry. Besides the heavy taxes, which have been paid on the property, by this company, and the natural increase in value of neighboring lands, a small settlement has been established, in the heart of a heretofore sparsely settled portion of the country; new roads have been built, old roads have been improved, streams have been bridged, a saw-mill has been erected, and, by the generosity of the mine owners, three months have been added to the regular school term.

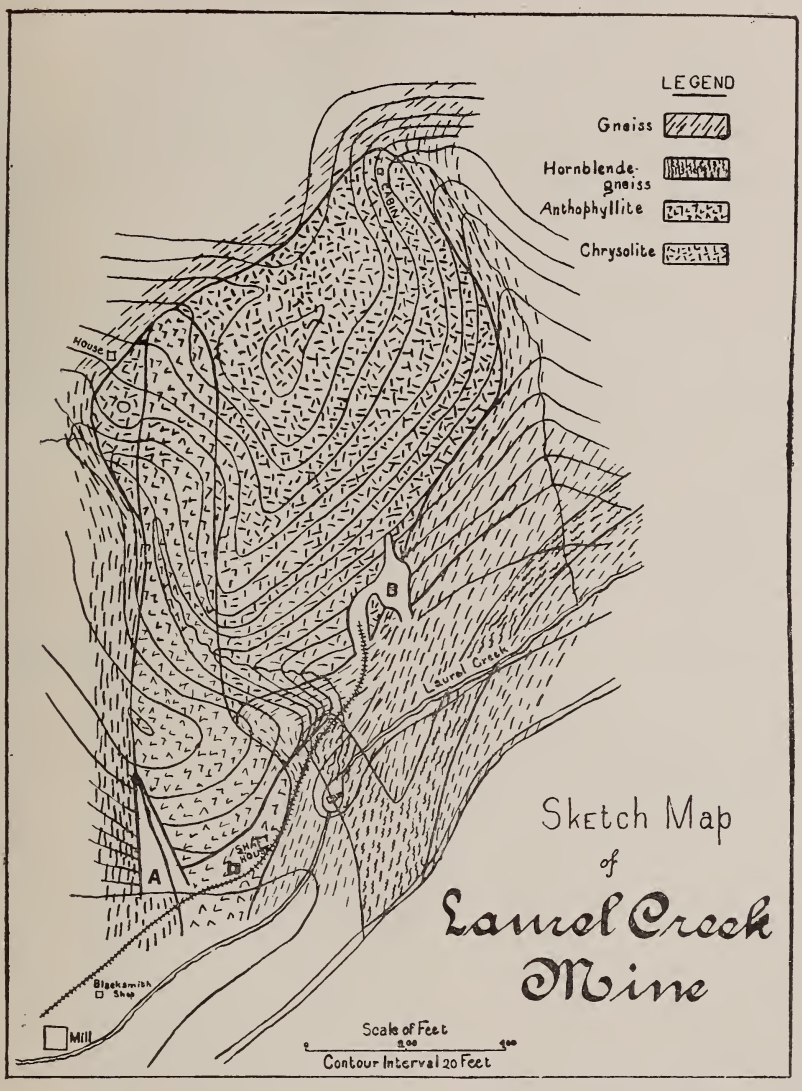
Location and General Features of the Mine.—The Laurel Creek corundum mine, or "Lucas mine," as it is locally known, is situated in the southern portion of lot 72, 3rd district. Pine Mountain, the mining settlement, is about one mile southwest, and both are on the north side of Laurel creek, a small stream entering the west fork of the Chattooga river. It is for this creek, that the mine is named.

The sketch map[1] shows the position of the works, the relative position of the different formations, etc. From this, it may be seen, that the formation occupies two small hills. These stand out conspicuously to an observer, on account of their rough, barren nature and the rusty, ochre color of their rocky surface (so characteristic of chrysolite formations), offering, in external appearance, a sharp contrast to their environments.

The original works are represented in the "sketch map," by the irregular-shaped cut at the right, marked B. From a tunnel at this point, the immense crystals pictured in Fig. 2 were taken. From the same vein, have been also taken those immense specimens of massive corundum, for which the mine is famous. The triangular cut at the left, near the shaft-house, marked A, works

[1] See figure 6.

FIG. 6.



around the main vein, and is an excavation from the surface at the contact of the gneiss and the magnesian formation. This excavation extended around to the front of the hill, where the shaft-house

now stands; but it does not show on this map, because of the cave-in, already mentioned. The work of 1893 was an inclined shaft, running down to the base of this old excavation, a depth of 130 feet, and is located on the map by the shaft-house.

The mill of the mine is situated a few hundred yards southwest of the shaft-house. This consists of a stamp-mill and other machinery for crushing and cleaning the vein material. Water is the motive power, and this is supplied by a small mill-race, extending from a dam near the mine, along the hillside south of the creek, to the mill. Corundum in its matrix is transported to this mill, by means of a tram-way, where it is cleanly separated and packed in barrels; it is then hauled to Walhalla, S. C., a distance of twenty miles, where it is shipped to the Chester factory, in Massachusetts.

GEOLOGY OF LAUREL CREEK.

Three types of rock are represented at Laurel Creek: —

1. Gneiss.
2. Hornblende-gneiss.
3. Peridotite. { Chrysolite, with a little chromite. / " more or less serpentinized, and associated with chromite. / Anthophyllite. } Dunyte.

The position of all these types at Laurel Creek may be seen in the Sketch Map, Fig. 6.

Gneiss is the main inclosing body, and, as may be seen by the map, in the immediate vicinity of the magnesian body, its strike conforms to the shape of the inclosed mass. It consists of a schistose or stratified aggregate of feldspar, mica and quartz, differing from the mica-schist, in having a less foliated structure, and from granite, in the lamellar arrangement of its constituents. The stratification of the gneiss is accentuated by light and dark bands, sometimes several feet in width, with, occasionally, a pegmatite vein or a coarse-grained aggregate of the same.

At the contact of this gneiss with the intruded peridotite, we should expect a zone of metamorphosed material; but this is not visible. Evidently, therefore, this region has been much disturbed

PLATE III.

Corundum at Base of Chlorite Schists.
Cut at Bell Creek Mine, Hiawassee, Towns County, Georgia.

by earth movements, since the magnesian rocks became a part of its structure; and the original features have given place to later changes.

Hornblende-gneiss lies on the eastern side of the peridotite formation. Outcroppings occur on the south side of Laurel Creek, and northeast of the shaft-house, where the tram-way cuts the base of the hill. At the latter point, we find the limit of an extension, or apophysis, from the main body lying to the east. The cut at the tram-way also shows the curving strata of the hornblende-gneiss, as it conforms to the elbowing gneiss.

The peridotite body is seen to consist of two well divided areas. The northern hill consists mainly of chrysolite. Fresh material, taken from the cut at B, is composed essentially of massive chrysolite, with a small percentage of magnetite and chromite. Hand specimens show a rock of granular structure, the grains varying from minute to a quarter of an inch in diameter. In color, the rock is mottled-green. On freshly fractured surfaces, the chrysolite grains present a very distinct cleavage and a vitreous lustre. Microscopic sections show that the chrysolite is somewhat altered, by the presence of small serpentinized cracks, chlorite and magnetite.

A chemical analysis of this rock, by Dr. William H. Emerson, gave the following results: —

Chemical Analysis of Chrysolite.

SiO_2	42.71 [1]
MgO	41.18
FeO	6.83
Al_2O_3	0.70
NiO	0.32
MnO	0.09
CrO	trace
Ignition	8.38
	100.21
Sp. Gr	3.10

[1] The silica contains a small amount of chromite, which was not determined.

The exterior portion of this chrysolite body consists of compact, fine-grained, olive-green rock, with phenocrysts of calcite and the calcium-magnesium amphibole, tremolite. Through these rocks, also, are visible dark streaks of magnetite. A microscopic examination reveals, that the chrysolite veins are completely broken up by serpentinization and the development of magnetite and chromite.

The anthophyllite, which occupies the southern portion of the peridotite formation, and tongues north through the chrysolite, is supposed to be an alteration product of the chrysolite. It will be seen by the map, that this makes up about one-third of the entire peridotite body.

The rock consists essentially of fibrous anthophyllite, magnetite and scales of a bright green chlorite, with talc occurring in it, occasionally. Its color is brownish green. The specific gravity is noticeably heavy. On account of its fibrous character, it is frequently spoken of as "asbestus rock."

It is much to be regretted that, at the time of survey, the condition of the mine was such, that access to tunnels etc., was impossible.

Dr. Chatard, however, who spent some time at this mine preparatory to writing his bulletin on "The Gneiss-Dunyte Contact of Corundum Hill, N. C., in Relation to the Origin of Corundum," writes:—"The two localities are alike in respect to the occurrence of the corundum. In both, the mineral is found in chlorite and vermiculite, lying between hornblende-gneiss and altered dunyte. At Laurel Creek, the open cut, in which the corundum is mined, runs east 10°, 20° north, following the course of the veins, the mine being situated on the north bank of Laurel Creek, at the base of a high hill. On the south bank and in the bed of the creek, hornblende-gneiss is the country rock, succeeded as we go northwardly by enstatite, talc and allied minerals. The corundum, first met with, occurs in what is locally known as the "sand vein," which is composed of chlorite and vermiculite carrying more or less corundum, usually in small crystals and fragments. The chlorite in the upper portion of this vein was much disintegrated; the mass, falling readily to pieces, allows of the easy removal of the corundum; but, at the time of my visit, it was very compact and tough, and of little value. The sand

vein is succeeded by a so-called "horse" of steatite, on the other side of which is the vein of "block corundum." This is a vein of vermiculite containing masses of corundum, sparingly mixed with chlorite and vermiculite, and frequently of great size, several having been obtained, of at least 5,000 pounds in weight. One mass, which I saw, must have weighed at least a ton. The north wall of the block vein is a smooth wall of "indurated talc" and steatite, which gradually passes into altered, but still hard, dunyte. Indeed, the difference between this place and Corundum Hill is in no respect more marked, than in the greater hardness and toughness of the corundum-bearing rocks, and in the apparent concentration of the corundum into large masses, with but little evidence of crystallization. At the western end of the cut is a vein of decomposed white material, shown by analysis to be an altered soda-lime feldspar. In this, I did not find any corundum; but I was told, that it was occasionally found in this rock."

This description of those features, which he desires to bring out, would tend to confuse an observer. It will be seen by the map, that the hornblende-gneiss does not come in direct contact with the dunyte; but there is an intervening formation of gneiss. Moreover, the mineral, corundum, is not confined to vermiculite and chlorite, if the report of the miners is to be credited; but it is abundant in the lime-soda feldspar. The testimony was corroborated by the presence at the mill of several tons of feldspar, thickly studded with corundum.

THE HICKS ASBESTUS MINE.

Lot 81, *3rd District.*

In the range of lots north, and cornering the land lot of the Laurel Creek mine on the east, is a formation, similar in character, known as the Hicks Asbestus mine. The formation, however, is much smaller apparently, a little over half as large. Corundum is reported to have been found here in small quantities; but the discoverers are said to have "salted" the property, with specimens from the Laurel Creek mine.

Considerable asbestus was taken away, and shipped, eight or ten years ago; and since then the property has been abandoned.

It is supposed to be a continuation of the Laurel Creek formation; but this cannot be proven by the outcroppings. It is true, that the same gneissic hornblende dyke passes on one side of these two properties; further than that, there is no connection.

LOTS 27 AND 28, 3RD DISTRICT.

This property belongs to the Nicholson heirs, living in the vicinity of Pine Mountain. It was worked for asbestus about the same time as the Hicks property.

The outcroppings are in the form of large bowlders of a talcose anthophyllite, similar to that found at the Laurel Creek mine; but outcroppings of like character may be found at intervening points, from Laurel Creek, alongside the same gneissic hornblende dyke.

This property is mentioned, because corundum is reported to occur here.

BEAVETT'S MINE.

Lot 177, *2nd District.*

This property belongs to Capt. Beavett of Rabun Gap. The formation covers a little over an acre, and is made up of soapstone and anthophyllite. The development, which consists only of a "test-pit," is on the top of a little spur. Basic magnesian rock makes up the entire formation of this little spur, while on either side is gneiss. On the northeast side of the hill, hornblende-gneiss sweeps down, striking 35° west of south, and, with the gneiss, dips to the southeast.

At the bottom of the pit, under a large bowlder, several pounds of corundum were found in vermiculites. The largest crystals taken from this vein are not over one-third of an inch long and a quarter of an inch in diameter. All are prismatic, and thoroughly impregnated by scales of vermiculite. After this discovery, work was abandoned. On the same lot and the adjoining north lot, a larger and more favorable formation occurs.

LOTS 177 AND 188, 2ND DISTRICT.

The magnesian rocks on this property extend over about two acres, and are made up of chrysolite and anthophyllite. The strike of the formation is about 45° west of south. Its greatest width is

at the northeast, where it is about one hundred and fifty yards wide, measured at right angles to the strike. The formation maintains this width, as well as can be determined, for over two thousand feet, when it pinches out.

The country rock is gneiss. Hornblende-gneiss is also present, as with other formations of similar character in Rabun county. Both types of rock dip sharply to the southeast, and strike southwest.

Very little work has been done on this property; and, up to the time of survey in the Fall of 1893, no corundum had been found. At this time, Mr. J. A. Lamb and his crippled son, who live close by, were digging a few holes; but, having comparatively little knowledge of prospecting for corundum, their toil was fruitless. Following, however, the lines of rock pointed out to them by the writer, a few days' work opened up a vein eighteen inches wide, in which small granular and crystal corundum was quite abundant. The vein was of the first type, that is, a gangue of kaolinized feldspar, quartz and phlogopite. Two inch walls of chlorite inclosed the vein on either side. The corundum was found in "pockets," lying close to the west wall. No corundum was found in the chlorite wall. This vein is situated in the extreme northeastern part of the magnesian formation, and within a few feet of the contact with the gneiss. It increased in width, as the workmen enlarged the pit, and offered good prospects for a formation of this size. Only a few pounds of corundum were washed out, and then the work was left for the inspection of possible buyers.

The corundum taken from the vein is grayish-white, grayish-blue and dark-gray. It was without crystal form usually, and not encased by any mineral; hence it was easily cleaned from the vein matrix. The specimens in the possession of the Survey are minute crystals, of prismatic and pyramidal type, and irregular grains, all showing the characteristic lines of pseudo-cleavage.

LOT 157, 2ND DISTRICT.

In the lot on the north side of the ridge at Lucius Garland's house, is a large outcropping of peridotite, known to the neighboring people as "Soapstone Mountain." Its length on a north and south line is about 300 feet, its width 100 feet.

The outcropping consists mainly of talcose anthophyllite. Its country rock is gneiss and hornblende-gneiss.

This property is mentioned, because of its size and the fact, that no prospectors seemed to have worked upon it. This neglect by prospectors is due, in all probability, to the ignorance of its character, on the part of those acquainted with its existence, and to its inaccessibility. No corundum had been found here, at the time of our visit; but the property is worthy of investigation.

LOT 7, 1ST DISTRICT.

No corundum has been found in this district, and of the properties examined, only one seems worthy of special mention—lot 7. This property is said to belong to Dr. H. V. M. Miller of Atlanta. It was worked, several years ago, by Mr. Ashbury, for asbestus. Considerable asbestus is said to have been mined, before the work was abandoned.

This peridotite formation is about five hundred and fifty yards long and two hundred yards wide. It is made up, as far as can be determined, by outcroppings, entirely of chrysolite, changing into chromiferous chrysolite at the northeast. It differs, therefore, from other peridotite formations in Rabun county, by the absence of anthophyllite. The country rock is gneiss, while hornblende-gneiss lies close by, on the northwest side.

All the mining for asbestus was in the nature of deep open trenches, confined to the southwestern, and central portion of the formation, but some distance from the contact with the gneiss. No corundum veins were cut by these; and, in the light of present knowledge, this result is not surprising. Until, therefore, prospecting has been carried on, near the contact with the gneiss, this property should not fail, for lack of a little development.

TOWNS COUNTY.

The known corundum deposits of this county are confined to the western side of the 18th district, and the eastern and central portions of the 17th district. Those of the 18th and the eastern portion of the 17th lie within a few miles of Hiawassee, the county-seat, while the remainder are in Brasstown Creek valley and vicinity.

THE BELL CREEK MINE.

Lot 6, 18th District.

This is one of the richest and most interesting little properties in the State. It is located about four miles north of Hiawassee. Its extent, concealed by surface disintegration, exploration has not determined, since testing has been confined entirely to the outcropping, which is not more than one hundred feet in diameter. A short time previous to the survey, the walls of the main pit had been blasted in, by an irascible prospector, for fancied injuries at the hands of the owner. He did not disturb the dump, however, which is full of granular corundum up to the size of a half inch in diameter. In his mining, such small pieces were evidently considered unworthy of notice. From this, the nature of the veins was determined.

The outcropping is made up of chrysolite, anthophyllite and chlorite-schist. Gneiss and hornblende-gneiss form the country rock, as shown by the soil and by small outcroppings of the former, on the eastern side. The main pit, already mentioned, was about twelve feet in all dimensions, and was sunk through chlorite-schists. These are stratified, and dip about 45° to the southeast. The vein follows the stratification of the chlorite. Plate III shows one of the walls of this pit, with a small exposure of the vein, in the lower left hand corner. The gangue of this vein is kaolinized feldspar. This is rich in beautiful pink corundum. In the dump, pink corundum was found in the wall material (compact, scaly, dark-green chlorite); but, at this small exposure, it does not show, in the three-inch wall.

The dump of another pit (the pit itself was full of water) revealed the presence of the fourth type of vein—a massive aggregate of pink corundum and light green smaragdite with feldspar. As a

cabinet specimen, there are few rocks prettier than this. The owner of this property, Mr. Wm. R. McConnell, was not able to give any information, in regard to the character of its occurrence, which is unfortunate, since this is the only specimen of the class found in Georgia. Moreover, its presence seems to be confined to only a few localities in this country. The specimens, obtained for the Survey, differ slightly from material in our possession, from Buck Creek, North Carolina; the amphibole is a little lighter green, while the corundum does not attain the deep ruby color of the Buck Creek variety.

THE HOG CREEK MINE.

Lot 92, 17*th District.*

The Hog Creek mine is situated on the northwestern portion of lot 92, about two miles west, a little south, of Hiawassee. More work has been done on this property, than at the Bell Creek mine, because of its greater extent and prospects. A trench, east and west, exposes the character of the formation, and several pits have been dug in close neighborhood, in the search for veins. Despite these, there has been little development; and, although the prospects are bright, an approximation of its value will necessitate further development.

Pink corundum prevails here, as at Bell Creek; but the veins in sight are not so rich. It is from this mine, that the Georgia rubies were taken. The writer was informed by the owner, Mr. William R. McConnell, that those found by him were small prismatic crystals of good color, but cloudy. Blue and grayish-white corundum is also found here.

The vein now exposed is about four feet wide. It is of the first type, that is, a matrix of feldspar, quartz and phlogopite, and lies in chlorite-schist. Both the vein material and the chlorite-schist are much decomposed through superficial disintegration. Plate IV shows the vein with the inclosing chlorite-schist. The strike is about 30° east of north; and its dip is 70° southeast. The cut follows this vein about twenty feet, and goes down on it eight feet. Corundum is present, not only in the feldspar gangue, but also in the chlorite walls; when in the latter, it has a pink color.

Corundum Vein, Hog Creek Mine, Hiawassee, Towns County, Georgia.

Besides chlorite-schist, the formation is made up of chrysolite and anthophyllite; these latter show in the form of surface bowlders. Gneiss and hornblende-gneiss surround the formation.

From a mineralogical standpoint, this locality is interesting, in being the only corundum locality known in Georgia, where the mineral zoisite occurs. The specimen now in the possession of the Survey represents a portion of what was, before it was broken by the workmen, a surface bowlder of zoisite, encased in finely fibrous actinolite, over a foot in diameter. Sheets of the latter also spread through it, forming a base for the slightly radial, columnar arrangement of the needles of zoisite. Actinolite, in the form of minute light-green needles is, besides, occasionally found interlined with the needles of zoisite. Dr. Genth [1] has described zoisite as an alteration product of corundum; but no corundum is present on this specimen. In the future developments of this property, zoisite will probably be found *in situ*, and its relation to corundum may here be revealed.

On account of its rarity and the fineness of the specimen, an analysis [2] was made, with the following results: —

SiO_2	38.29
Al_2O_3	33.38
Fe_2O_3	1.51
CaO	24.19
MgO	0.93
Ignition	1.80
Alkalies	Undetermined.
Total	100.10
Sp. Gr.	3.35

Occurring on this lot, also, and as probably a continuation of the formation, is an outcropping of chromite, in which a chrome-ore vein has been opened. Genthite [3] is also present, as an incrustation on chromite. Some large blocks of feldspar, thickly studded with corundum crystals, were found in this cut, apparently *in situ*.

[1] See zoisite, page 46.

[2] Analysis by Dr. William H. Emerson.

[3] See page 56.

LOT 42, 23RD DISTRICT.

This lot belongs to Mr. J. N. Gibson of Hiawassee. Two distinct magnesian formations extend through it; and, on both, corundum has been found. In the fields southeast of his home, in the southwestern corner of this lot, a shaft ten feet square was sunk, several years ago. Corundum was found; but, the find not proving satisfactory, work was abandoned. Surface disintegration is quite deep here, and the only clue to the occurrence of corundum was its presence on the surface. In the northwest corner of the same lot, on a formation distinct from that of the southwest corner, a type of vein, different from any previously described, was exposed by Mr. Gibson. This vein is of the third type, and is massive-porphyritic in character. It is made up of large[1] hypidiomorphic crystals[2] of a black hornblende, with lime-soda feldspar, and irregular grains of grayish-white and blue corundum, frequently an inch or more in diameter. The hanging and foot walls are massive hornblende. Bowlders of this appear on the surface; but no outcroppings occur.

If this vein, which is about four feet wide, continues as uniformly rich in corundum, as present work forecasts, its economic value does not seem doubtful. Increase in the expense of working, as compared with that of the usual veins, will probably be compensated for, by the greater abundance of corundum.

OTHER CORUNDUM PROPERTIES NEAR HIAWASSEE.

Here are included lots, on which surface-corundum has been found; but no prospecting nor any attempt at development has been made. Outcroppings, if present, are small; and surface disintegration and "wash" have completely concealed the real extent of the formations. Following are the lots:—

Lots 4, 5, 34, 35, 36, 41, 43, 73, 17th district, and lots 89, 90, 91, 18th district.

[1] These crystals are often several inches in length and an inch or more in width.

[2] That is, crystals only partially bounded by crystal planes.

THE HAMILTON MINE.

Lot 60, 17th District.

The Hamilton mine is noted mainly for the lawsuit, in which it has been involved for several years past, and the large sum of money spent by Mr. Hamilton in its fruitless development, as brought out in court. It is located about five miles north of Young Harris, on a western spur of a range of hills forming the western boundary of Brasstown Creek valley, trending north and south, and culminating, at the south, in the highest peak in Georgia, Mt. Enota.

The works are located on the top of this spur, and consist of several prospecting pits, and a perpendicular shaft about 100 feet deep.

The formation is similar to that at Track Rock, though smaller. Its greatest width is in the saddle of the spur, pinching out rapidly, as it descends the spur on either side. The rocks brought out from the shaft are of the same type as those described at the Track Rock mine.[1]

The corundum, as at Track Rock, occurs encased in margarite. Sometimes the margarite scales lie flat upon the corundum, while other specimens show a zonal arrangement, with upturned edges, the latter type being more apparently an alteration of the corundum. Specimens of the actinolite-margarite rock were here found, containing corundum; otherwise the vein matrix for corundum was the same as at Track Rock. A section of the material penetrated by the shaft could not be obtained.

BRASSTOWN CREEK VALLEY CORUNDUM PROPERTIES.

These properties represent an almost direct southwest line of basic magnesian formations, extending through the Hamilton property, and connecting with the formations leading on to Track Rock, Union county. They occur on lots 23, 50, 60, 84, 85, 97, 118, 119, 135, 171, 190, 17th district.

[1] See pages 93 and 94.

UNION COUNTY.

Only a few deposits of corundum have been found in Union county, and these lie in the northwestern portion of the county. In this county, however, the almost continuous line of deposits of Brasstown Creek valley, Towns county, culminate in possibly the second largest peridotite formation in Georgia, the Laurel Creek mine ranking first. In this deposit is the Track Rock mine.

TRACK ROCK MINE.

Lot 259, 17*th District.*

Track Rock mine is located on the south side of Track Rock gap in the northeastern portion of Union county. The mine has been developed only partially; but already it shows excellent prospects. A large mill is conveniently located near the entrance to the tunnel. Water for washing the vein matrix is brought by an acqueduct from a little stream close by. The machinery, by means of which the company separates the corundum, is run by steam.

The present development is a tunnel to the right of the mill,[1] which enters the magnesian formation from its eastern side.

The company has penetrated the formation about two hundred feet, branching out at several points. Although the tunnel is slightly inclined, to permit good drainage, they have, by this means, reached a depth of seventy-five feet from the surface level at the extreme end of the tunnel.

The formation differs considerably from the class of formations, represented by the Laurel Creek region. From a superficial inspection of this property, one would conclude, that the formation is made up of talcose-chlorite schists to the complete exclusion of chrysolites. Instead of a barren area of anthophyllites and serpentinized chrysolite, as at Laurel Creek, we are here confronted by a heavily wooded area, over whose rich soil are scattered large bowlders of a talcose chlorite or "blue soapstone," as it is locally termed.

The presence of corundum on such a formation tended to confuse preconceived ideas of the nature of corundum-bearing forma-

[1] See Plate V.

tions in the North Carolina–Georgia region. Corundum prospectors, moreover, have come to speak of the Track Rock mine as a "chlorite mine," in contradistinction to a "chrysolite mine." The Survey, however, found that these chlorites were simply a secondary feature, since most of the material taken from the tunnel, which had been passing muster for chlorite, was really a bright green amphibole, actinolite. Among the rocks taken from the mine, is a dark-green, finely granular rock, which was supposed to be massive chlorite.

This latter rock is most interesting, because it affords a key to the mystery of the formation. Instead of being massive chlorite, it is an altered chrysolite, consisting of fine blades of actinolite, small granules of chrysolite, and an abundance of magnetite. A thin section, examined under the microscope, shows that the chrysolite has undergone extensive change. Cracks in the remaining chrysolite grains are widely extended, and are filled in by actinolite (?), while small grains are completely isolated by enclosing actinolite. The large percentage of magnetite is also probably due to the alteration of chrysolite.

On account of the close timbering of the tunnel, it was impossible, at the time of survey, to see the sequence of formations penetrated, but the foreman, Captain R. J. Cook, who is now living on the property, had kept a record of these, from which, together with the dump and material obtainable in the tunnel, the following section was determined, viz: —

1. Thirty feet of micaceous gneiss.
2. Ten feet of talcose-chlorite schist.
3. Thirty feet of soft, greenish material and pearly white scales; the former, actinolite, the latter, margarite.
4. Four feet of hard, massive, dark-green rock, with gneissic structure, made up of actinolite and a lime-soda feldspar (oligoclase (?)). In this are bands of compact, scaly green chlorite.
5. Twelve feet of extremely disintegrated light-green material, consisting mainly of kaolinized feldspar, with a smaller proportion of light-green actinolite. Corundum is present in this.

6. Four feet of the same material as 4.
7. Twenty-four feet of material similar to 5. This is rich in corundum.
8. Four feet of material like 4 and 6.
9. Ten feet of material similar to 5 and 7, but not so rich in corundum.
10. Forty feet of lime-soda feldspar, in which hard bunches of feldspar remain unkaolinized. Mica (phlogopite) is scattered through this, but no trace of quartz.
11. Ten feet of talcose-chlorite schist.
12. Twenty feet of the soft, decomposed material like 5, 7 and 9, with some corundum.

The altered chrysolite, described on page 93, does not appear in this series; and, unfortunately, its position could not be learned.

Although, this section is doubtless wanting in considerable detail; nevertheless, from this series, such as it is, a few interesting and important facts may be observed:—(a) the new phase of alteration in the chrysolite; (b) the absence of anthophyllite rocks; (c) the presence, in close vicinity to each other, of broad parallel corundum veins; (d) the character of these veins; and finally, of marked significance, (e) the presence of these veins near the gneiss contact.

All the material, mentioned in the above section of Track Rock mine, may be duplicated at the Hamilton mine, and will probably be found, on the development of any of the corundum properties, extending through Brasstown Creek valley. The chrysolite of the Hamilton mine is of a lighter shade of green, than the one described here; but this is probably due to its less altered condition and its smaller percentage of magnetite.

The formation at Track Rock mine strikes southwest 30°, and dips to the southeast about 40°. The corundum veins lie in the stratification of this formation, and conform to its structure. None of these veins have been followed any distance; but, during the brief period of work, preceding the financial troubles of the summer of 1893, when work was stopped, several tons of corundum

were cleaned and shipped to the mills of the owners, "The New York Corundum and Mining Company."

The corundum obtained from the veins is in small irregular pieces, encased in a mantle of pearly, grayish-white margarite.[1] The process of cleaning and preparing this corundum for shipment will be described in the chapter on "Economics."

OTHER CORUNDUM PROPERTIES IN UNION COUNTY.

Lots 208, 244, 282, 295, 318, 17*th District.*

All these lots have been indifferently prospected for corundum. The amount found, however, and the lack of interest on the part of speculators has not enthused the owners to put any time or money into their development. Outcroppings of the basic magnesian rocks are small, if present; and deep surface disintegration characterizes the majority.

THE STONE MINE.

Lot 246, 17*th District.*

This property lies in the southeast corner of lot 246 on the north side of Track Rock gap, and on the east side of the road. It is a part of the Track Rock formation, and presents no differences, except in size. A twenty-foot tunnel, running from the road into the hillside, passes through talcose-chlorite schist into brownish-yellow banded, but completely disintegrated, material, through which, parallel with the band, are stripes of feldspar containing corundum.

The development is too slight to offer any assurance of its value. The formation, however, is large enough to induce further prospecting, and some good veins may be developed. This property belongs to Mr. J. H. Stevens, and it was under option to northern parties, represented by Mr. Robinson of Young Harris.

FANNIN COUNTY.

Corundum has been reported from this county; but no occurrence is yet known to the Geological Survey.

[1] This was determined by Dr. Emerson, from a partial analysis.

GILMER, PICKENS AND DAWSON COUNTIES.

Corundum is not known to occur in any of these counties; but it is quite possible that it may be found in Dawson.

LUMPKIN COUNTY.

Corundum was first found in Lumpkin county, in the summer of 1894. Only one locality is known.

Lot 249, 15*th District*, 1*st Section.*

About one mile southeast of the summer resort, Porter Springs, on the eastern side of lot 249, a low outcropping, seventy feet wide and two hundred feet long, was discovered by a child to contain corundum. This property belongs to Charles Cain, whose home is but a few yards from the outcropping. A prospector had given Mr. Cain's little boy a piece of corundum, with the injunction, "Dig for it in those green rocks, and make your fortune." The little chap went to work bravely, and his scratching was rewarded by a few pounds of grayish-white, blue and pink blocks of corundum.

The formation consists of massive hornblende. No work has been done to develop the property, and its size and prospects will probably not warrant the expense.

WHITE COUNTY.

Corundum has not been found in White county; but the corundum deposits of Habersham county are close to the northwest boundary; and, furthermore, basic magnesian formations continue on into White county from this vicinity, and are known to occur at several other points in that county. Careful prospecting will undoubtedly reveal in some of these the presence of corundum.

HABERSHAM COUNTY.

The first authentic knowledge of the occurrence of corundum in Georgia seems to have been the mention of a specimen from Habersham county. It is only in the past year, however, that an active search has been made for corundum in this county; but, in that brief time, its distribution is, perhaps, as well known, as that of any other section of the State. This is due almost entirely to the tireless energy of a few men, prominent among whom may be mentioned Mr. Thomas S.

TRACK ROCK CORUNDUM MINE, TRACK ROCK, UNION COUNTY, GEORGIA.

Bean of Clarksville, and Messrs. A. J. Lyons and William Trotter of Soque. The information of the latter is confined to the northwestern portion of Habersham county, while Mr. Bean is well versed in the mineral resources of the whole county.

The known corundum properties of Habersham may be said to lie in the Aleck mountains, a small range in the northwestern part, of the county. Despite, however, the number of occurrences in this section, there is not a property, which has been developed, and only a few, on which any work has been done. This is accounted for, not by reason of a lack of interest or faith on the part of those controlling the property, but on account of the unfortunate coincidence, that, at the time of discovery, capital was panic-stricken, and the corundum industry, in both North Carolina and Georgia, was at a stand-still. Nevertheless, when this industry is resumed, there is no doubt, but that some of these properties will receive careful attention.

PROPERTIES ON WHICH CORUNDUM HAS BEEN FOUND.

Lot 118, 11*th District.*

This lot is owned by Mr. E. P. West of Clarksville. Mr. E. T. Whatley, formerly Assistant State Geologist, had a small ditch dug across the small outcropping of peridotite in this lot, and he is reported to have found several pieces of corundum.

Lot.	*District.*	*Owner.*
125	11*th*	*E. Kimsey.*
126	"	*F. R. Asbury.*
127	"	*John Elder and John Tatum.*
131	"	*John Elder.*
132	"	*G. B. Elder.*
133	"	*Wm. Trotter, James Stroud, F. E. McCracken, Tillman Worley and E. Kimsey.*

In the lots enumerated above, some surface-corundum has been picked up; but no work has been done, except in the last. The formation extending through them, the outcroppings show to be chlo-

ritic; and it is probably similar in character to those of Brasstown Creek valley, Towns county, and Track Rock, Union county. Surface relations show this to be one hundred yards in width at several points. On lot 133, a trench 5 x 10 x 5 feet has been dug on the slope near the top of a small hill; and fifty pounds or more of beautiful corundum enclosed by margarite [1] has been taken out. The gangue of this corundum is reddish dirt, like the country material; and, on account of this superficial decay, it is impossible to tell anything about the character of the body, through which it is disseminated.

These specimens of corundum have attracted considerable attention, on account of their beauty. When taken from the pit, they resemble externally lumps of white clay; broken open, however, a nucleus of beautiful red corundum, with a zonal mantle of delicate pale-green margarite is revealed.

Lot 134 is interesting, on account of the presence here of a vein of the third type, consisting of black hornblende, lime-soda feldspar and corundum, as shown by surface specimens.

LOT 16, 3RD DISTRICT, LOT 129, 11TH DISTRICT, AND LOT 17, 16TH DISTRICT.

Through these lots, belonging to Mr. A. J. Lyons, a small magnesian formation extends, and several pieces of block corundum have been found while ploughing.

Information, in regard to any of these occurrences in Habersham may be obtained from Mr. Lyons or Mr. Bean.

HALL COUNTY.

Corundum is known in Hall county only at one locality. Beautiful red pieces of corundum have been found, for many years, by gold washers, in a small stream one mile west of Gainesville. Its source seems to have been recognized by a few; but it cannot be learned, that any specimens have been found, except in the sands of the stream. The locality has been well known to mineralogists for some time, not only on account of the beauty of the corundum, but because of the delicate green margarite found associated with it, an analysis of which, published by the chemist of the United States Geological Survey, is given on page 99.

[1] Determined by Dr. Emerson, from partial analysis.

The Survey examined this property in the summer of 1894, and found that the stream flowed by the eastern base of a small hill; that the backbone of this hill consisted of magnesian rocks; and that, at the northern end of the formation, in the ploughed field, north of the old road leading over the hill, corundum, associated with margarite, was abundant. Previous to this time, the presence of corundum on the hill had escaped the notice of its owners, because of the margarite mantle. There, the dull, dirty, nodular bowlders in the field—some of them as large as a man's head—failed to attract the attention of those looking for the bright, glistening, red corundum of the stream-sands below, when a blow of the hammer would have revealed the object of their search.

The specimens of this material, now in the collection of the Survey, range from one to six inches in diameter. Through these are scattered grains of corundum from a quarter to one and a half inches in diameter. Around these grains the margarite is zonally arranged; and, if not an alteration of the corundum within, it certainly resembles it.

The margarite in these specimens is grayish-white to a delicate pale-green in color. The zones are made up of small, pearly, radiating scales, with their edges tangential to the corundum nucleus. An analysis[1] of this mineral shows :—

SiO_2	32.15
Al_2O_3	49.28
Fe_2O_3	0.57
CaO	11.09
MgO	0.63
Na_2O	1.18
K_2O	1.04
H_2O	4.16
	100.10
Sp. Gr.	3.004

[1] Analysis made by Dr. T. M. Chatard, and quoted by Clarke, Am. Jour. Sci., 3rd series, Vol. XXVIII., 1884, p. 22.

The formation consists of pale greenish-white chlorite-schists and anthophyllite; large bowlders of the latter occur on the south side of the old hill road.

An analysis of the chlorite-schist was made by Dr. George A. Koenig, because, on account of its color, it was thought to be a talc-slate. He found it to be a true chlorite-schist, containing : —

SiO_2	30.33
Al_2O_3	20.90
Fe_2O_3	4.00
FeO	4.11
MgO	27.79
Ignition	12.62
	99.75

The strike of the chlorite-schist is 25° west of north; the dip is 45° to the southwest. This is a rare instance of the deviation of these structural features from the normal structure of the Crystalline Belt. Several deep pits have been sunk on the south side of the road, in an attempt to find good asbestus veins. This seems to have been a failure, the asbestus veins exposed being small, and the quality inferior.

The formation is about a quarter of a mile long and 100 feet wide. Though small, the abundance of corundum, that has been found here, should induce testing. Its close proximity to Gainesville, with her supplies and railroad conveniences, would probably sustain the development, even if the output was small, when a much larger mine would fail, for lack of such facilities.

This property is controlled by Major Theodore Moreno of Gainesville.

FORSYTH COUNTY.

The occurrence of corundum in Forsyth county was first noticed a year ago. Its presence here, except in one instance, is peculiar, in so far as the only known trace of its existence is its presence.

LOT 1,274, 2ND DISTRICT.

This lot is about one mile north of Sheltonville, and belongs to

Mr. Tuggle, Jr. Corundum has been found in his yard, both by himself and by neighbors, although mica-schist and garnetiferous hornblende-gneiss are the only types of rocks in the vicinity.

LOT 447, 1ST DISTRICT.

Corundum is reported to have been found on this lot; but its presence is very questionable.

LOT 776, 2ND DISTRICT.

Several little blocks of corundum were found by the writer on this lot, close by some small anthophyllite bowlders. Beyond the presence of these bowlders, all evidence of a basic magnesian formation is concealed. The occurrence is evidently of no economic importance.

CHEROKEE COUNTY.

A corundum deposit is reported east of Ball Ground; but we were not able to locate the property. It is quite probable, that some deposit will be found in the eastern part of this county. On Mr. S. J. Blackwell's property, lots 36, 37 and 108, 2nd district, 2nd section, there is an extensive formation of Pyroxenite (?), in which some large veins of asbestus have been exposed. Outcroppings of a similar character, but smaller, extend north several miles. No corundum has yet been observed.

COBB COUNTY.

In this county, corundum has been found only in the southwestern corner.

LOT 1236, 2ND SECTION, 19TH DISTRICT.

Mr. Elias Rogers, of Villa Rica, prospected considerably on this lot a few years ago, but without success. A little corundum is found scattered over the surface.

The property is owned by Mr. W. B. Westmoreland of Austell, Ga.

CORUNDUM IN THE VICINITY OF POWDER SPRINGS.

Surface corundum has been picked up in the vicinity of Powder Springs, on a "lead" extending from lot 684, which belongs to Mr. Henry Reeves, to Brownsville, Paulding County.

Outcroppings of basic magnesian rock are very rare, surface disintegration and wash, generally, concealing the formation. Only one point has been worked for corundum, a description of which is as follows: —

LOT 1271, 2ND SECTION, 19TH DISTRICT.

On the farm of Mr. W. B. Turner, about two miles south of Powder Springs, corundum occurs in workable quantities. At the time of the New Orleans Exposition, large surface specimens from this farm, which had been sent for exhibition, attracted the attention of a German syndicate, who, shortly afterwards, purchased the mineral interests of the property. Several months were spent in prospecting; and when a vein was finally exposed, work ceased.

This vein, between five and six feet in width, is of the first type. It lies between chlorite-schists, striking and dipping with the country rock. The strike is 50° east of north, and the dip 45° southeast. The vein is exceedingly rich in corundum, which is disseminated through it, in streaks, parallel to the dip of the vein, rather than in "pockets," and more thoroughly, than in any vein of this type, which has been exposed in the State.

The corundum of this vein occurs in small irregular grains, sometimes with crystal form. The color varies from grayish-white to blue and red. Its quality is eminently good. Surface specimens from this property often occur associated with blue kyanite.

Plate VI is reproduced from a photograph of the south side of the pit, showing the vein and the stratified chlorite-schists enclosing it. A geological hammer, with a 14-inch handle, stands in the center of the vein, for comparative purposes.

There seems to be no reason, why it would not pay to work this property. The vein is large, unusually rich, and can be easily worked for some time, on account of the disintegrated slate of the

matrix; and the property is within two miles of Powder Springs, a railway station, with an excellent wagon-road between the two points.

PAULDING COUNTY.

Corundum has been observed in the northeastern and southeastern corners of Paulding County.

On lots 533 and 534, 3rd district, 3rd section, and on the farm of Mr. William T. Prather, seven miles southeast of Acworth, surface corundum was found, a few years ago. This led to the purchase of the property by the Sapphire Valley Company of North Carolina. Since this prospecting, which consisted mainly of two vertical shafts, no work has been done by the company.

At the time of survey, these shafts were full of water; hence, the character of the formation penetrated is not known. There are no outcroppings close at hand; and deep disintegration marks the area.

The corundum is dark-blue and deep-pink in color, and is specially distinguished by strongly marked parting-planes and by its unusual softness. This latter property was overlooked, until a wheel, manufactured from it, was found to wear down with extreme rapidity under a piece of steel. Mr. E. W. Parker says: — "It is supposed that this variety of corundum contains a little water, as it is somewhat less hard and more easily cleavable than the common variety, known as sand corundum.[1]

Dr. Emerson, in the laboratory of this Survey, has made an analysis of a specimen of this corundum, with the following result: —

Sp. Gr.	4.20
Al_2O_3	94.58
SiO_2	1.77
Fe_2O_3	0.69
CaO	0.44
Water	2.51
	99.99

[1] Mineral Resources of the United States, 1893, pp. 676 and 677.

If this analysis be compared with the analyses of corundum by Dr. Smith,[1] it will be seen that the percentage of alumina in this corundum is very high, and the silica low, while the amount of water is lower than several; yet, the hardness of this corundum is between 5 and 7. Though readily scratched with a knife, it will itself scratch quartz. These facts lead to the suggestion, explanatory of this anomaly, of a possible secondary physical structure, which has greatly changed the cohesion.

CORUNDUM PROPERTIES IN THE VICINITY OF BROWNSVILLE.

In the notes on Cobb county, it is stated, that a "lead" extends from Powder Springs to Brownsville. This is based, in great measure, on hearsay evidence, since there has been no attempt at development along this line, except at W. B. Turner's in Cobb County. The southwest end of this "lead," or the last point, at which corundum has been found in the fields, is lot 456, 1st district, 3rd section, on Jacob W. Meadow's farm, a mile and a half south of Brownsville.

On account of the excellent prospect developed at Turner's, it is at least advisable, for the property owners, along this line, to interest themselves, in testing the lands, on which they find surface indications of corundum, since superficial disintegration and erosion have concealed the extent of these corundum-bearing formations; for a pretty prospect may be opened up.

DOUGLAS AND CARROLL COUNTIES.

Some surface corundum has been found in the vicinity of Villa Rica.

LOT 178, 6TH DISTRICT, DOUGLAS COUNTY, AND LOT 165, 2ND DISTRICT, CARROLL COUNTY.

The lot in Douglas county shows no outcropping; but that in Carroll county shows chrysolite and actinolite-talc outcroppings. The latter rock is made up of long crystals of actinolite, often as long as three inches and over one-third of an inch across, imbedded in pure granular white talc. Small veins of asbestus appear in the chrysolite.

[1] See page 30.

CORUNDUM VEIN ON TURNER'S FARM, NEAR POWDER SPRINGS, COBB COUNTY, GEORGIA.

On lot 118, 5th district, one and a quarter miles east of Carrollton, the county seat, close to the house of Mr. E. P. Worthy, corundum encased in margarite, similar to that found at Gainesville, was discovered by the Survey. A very small outcropping of chrysolite, with small veins of asbestus, occurs on the south side of the road. The corundum, however, was found in his yard on the north side of the road.

HEARD COUNTY.

LOT 44, 13TH DISTRICT.

This property belongs to Mr. William A. Hyatt, Central Harchee P. O. It contains a small formation of basic magnesian rock. From a small ditch across this, Mr. Hyatt uncovered several bowlders, weighing from fifty to one hundred pounds, and consisting of grayish-white and blue corundum in a matrix of black hornblende. Pink scales of margarite are also disseminated through the rock.

The size of the formation does not offer encouraging prospects; but the occurrence of corundum in this association is especially interesting.

TROUP COUNTY.

A short distance northeast of West Point, some northern parties prospected last year, over a narrow strip of peridotite rocks, which extend from the Chattahoochee River northeast, and outcrop intermittently, for about five miles. The object of their search was asbestus.

LOTS 286, 315 AND 316, 5TH DISTRICT.

The greater portion of the prospecting, mentioned above, was done on these lots, belonging to Mrs. N. H. Winston. Corundum has been picked up occasionally on these lots; and, from the dump of some of the pits, the writer picked up several small pieces of corundum, although no vein had been exposed, as well as could be determined from the character of the disintegrated material, forming the walls of the pits.

WALTON COUNTY.

It will be a matter of surprise to those, who consider the corundum deposits of Georgia to be confined to a narrow belt, following the course of the Chattahoochee River, to learn, that a deposit of corundum has been discovered in Walton County, some distance to the east of this belt.

LOT 160, 3RD DISTRICT.

Basic magnesian rocks are found at several points in Walton county; but, on this lot, the formation is quite wide. The only exposure is a small outcropping, composed of long, columnar crystals of bright-green actinolite in a slight matrix of steatite. At its widest point, the formation is about three hundred yards.

From this lot, over five hundred pounds of excellent block-corundum have been picked up, and shipped to the market. With the exception of a few small trenches, dug for asbestus, no effort at testing the property has been made. Nevertheless, the size of the property and the surface indications are encouraging for development.

The property is situated four and a half miles from Monroe, the county seat, through which passes the narrow gauge Social Circle and Gainesville Railroad. It is on the farm of Mr. George W. Breedlove.

ORIGIN OF GEORGIA CORUNDUM.

The study of the origin of corundum is still in its infancy. Scientists are not yet prepared, to offer more than hypotheses; for they have but started on that framework of facts, necessary to adequate theories and true conclusions. Hypothesis after hypothesis has been advanced; but only a few have sufficient foundation to justify second thought. Conservatism in conclusion, based on the few facts at our command, is therefore most necessary.

A single mode of occurrence is observed in Georgia ; that is, with the chrysolite formation extending through the Crystalline

Belt. The types of veins, containing the corundum occurring in these bodies, have been mentioned already in a preceding paragraph, as have also the geological environments of the chrysolites. Concerning the latter, it was noted: —

(1) That the chrysolite body occurred in gneiss or mica-schist.

(2) That in every instance, where it was possible to note the relations, hornblende-gneiss lay close at *one side* only; not enclosing the chrysolite, as stated by Julien[1] to be the case in North Carolina, nor in contact, as Chatard says, in his Bulletin.

(3) That the corundum-bearing veins lie in the chrysolite body, close to the contact, and in the vicinity of the hornblende-gneiss.

It has been observed, that, where all these conditions exist, corundum is present, often only in small amounts, and sometimes not at all. Corundum, therefore, seems to be essentially an accessory mineral, its presence being occasioned by an excess of aluminum present in the rock-masses, chrysolite, gneiss and hornblende-gneiss. Alterations of these yield, respectively, magnesium silicates, alkaline salts and ferro-silicates, which, together with the carbonic acid of the percolating waters, would dissolve the combined aluminum, and, on recrystallization, produce all the minerals mentioned as associates of corundum, and, in case of an excess of aluminum, the aluminum oxide, corundum. Predominence of any of the solution constituents would give character to the veins; hence the types which have been noted.

Chatard says: —[2] "Whether the solutions of soda and alumina must be heated, in order to effect the production of these minerals, is a question, to which, at present, no definite answer can be given; but it would seem, that the ordinary subaërial decay of these rocks should furnish the necessary solutions. The observations of Becker and the experiments of Barus show, that there is considerable doubt, as to any production of heat as a result of the kaolinization of feldspar; and, if such is the case with feldspar, it is not likely, that the alteration of any of the other mineral species present in these rocks

[1] A. A. Julien; The Dunyte Beds of North Carolina. Proc. Bos. Soc. Nat. Hist., Vol. XXII., 1882, p. 148.

[2] Bulletin 42, U. S. Geological Survey, p. 58.

would be attended by any marked rise in temperature. We must therefore conclude, that the gneiss can furnish an alkaline solution of alumina, and the dunyte, a solution of magnesia, without the production of heat, and, perhaps, without its aid."

Dr. Genth, from his admirable investigations of corundum, its alterations and associate minerals, concludes: — "That, at the great period, when the chromiferous chrysolite beds (part subsequently altered into serpentine etc.) were deposited, a large quantity of alumina was separated, which formed beds of corundum.

"That this corundum has subsequently been acted upon, and thus been changed into various minerals, such as spinel, fibrolite, cyanite, and perhaps into some varieties of feldspar; also into tourmaline, damourite, chlorite and margarite.

"That a part of the products of the alteration of corundum still exists, in the form of large beds of mica (damourite) and chlorite-slates or schists.

"That another part has been farther altered and converted into other minerals and rocks, such as pyrophyllite, paragonite, beauxite, lazulite etc."

The former hypothesis seems more in accordance with known facts; yet extended field-work and much laboratory investigation, concerning the nature of aluminum, in many instances so evasive, must be carried on, in the most careful manner, before we may hope to attain a tenable theory.

CHAPTER VI.

ECONOMICS.

HISTORY OF CORUNDUM MINING IN GEORGIA.

The history of corundum mining in Georgia is very brief. Only two mines have been operated in the State; and, at the present time, both are closed. The Laurel Creek mine began active work in 1880, and shut down in the summer of 1893. During the first twelve years, the production was eminently successful, and the mining of corundum in Georgia was considered an established industry; mining contretemps, however, followed by hard times, necessitated the cessation of work. The Track Rock mine is the other, which was operated in this State. Mining stopped here, a few months prior to the closing down at the Laurel Creek mine. Indeed, the period of mining was so brief, that it can be scarcely said to have been operated.

From several localities, corundum, generally picked up from the surface, has been shipped in small quantities, and prospecting has been carried on, in many places. The number of these prospectors attest the interest in the mineral displayed by the citizens.

VALUE OF THE GEORGIA DEPOSITS.

Individually, in certain instances, it would be unfair to attempt an approximation of the value of the corundum deposits of Georgia. In the majority of cases, little, if any, prospecting has been done; and, where there has been an attempt at development, such prop-

erties too frequently testify, that the prospectors had little aptitude for their work. Again, the formations are often obscured by sub-aërial decay and by detritus; they are also obscured by the cultivation of the soil. Until, therefore, the surface limits of the chrysolite formations have been defined, and prospecting has revealed the veins, whose decay left the insoluble corundum as evidence of their presence, just estimates are impossible.

Regarded as a whole, however, Georgia may well be proud of this mineral resource. It is probable, that very few large mines will be developed; but, for deposits of a mineral comparatively rare, and at present so much sought, for use in the arts, that the United States is not able to supply the home demand, the great number of small occurrences offer substantial hope for future revenue.

PREPARATION AND MANUFACTURE.

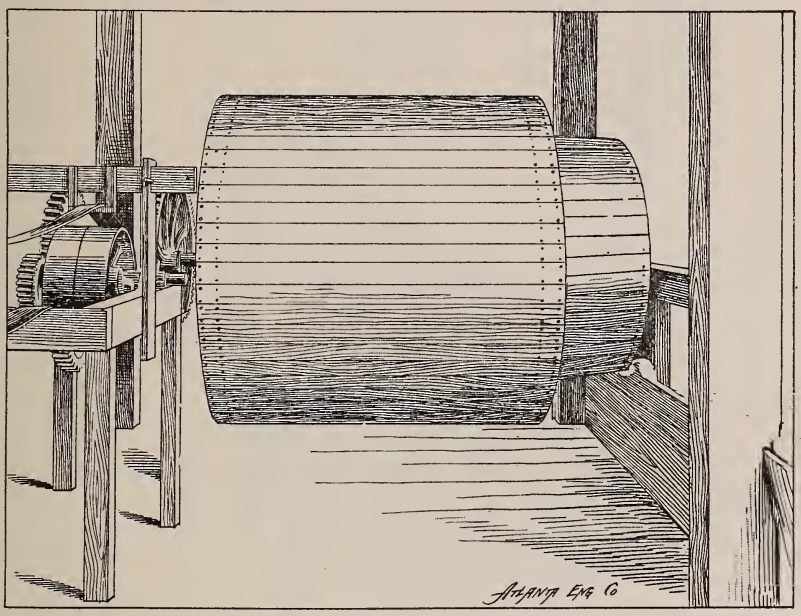
In the preparation of corundum, it is first necessary to free it from the accompanying gangue. If the gangue is hard, it is crushed, and then, like the disintegrated gangue, it is washed in a series of sluice-boxes or in a revolving washing-cylinder. The latter method of washing was devised by the Track Rock people, and is said to be a great improvement over the former method. The cylinder is barrel-shaped, and is about ten feet long and six feet across the largest part.[1] One end has an open neck attached, to permit the shoveling in of the material, while the cylinder is in motion. Into this end, also, a steady stream of water is introduced by means of a pipe. The other end of the cylinder is closed by a wire screen. A trap-door permits the ready removal of the corundum when cleaned.

The corundum at Track Rock mine cannot be thoroughly cleaned in this way, because of a hard zone of margarite around the corundum; hence it is introduced into another machine. This

[1] See Figure 7.

second machine is a small affair, as seen by figure 8. It contains two disks, armed with points, which are revolved with great rapidity. The zonal covering of the corundum, when exposed to this treatment, is worn off, almost completely.

Fig. 7.

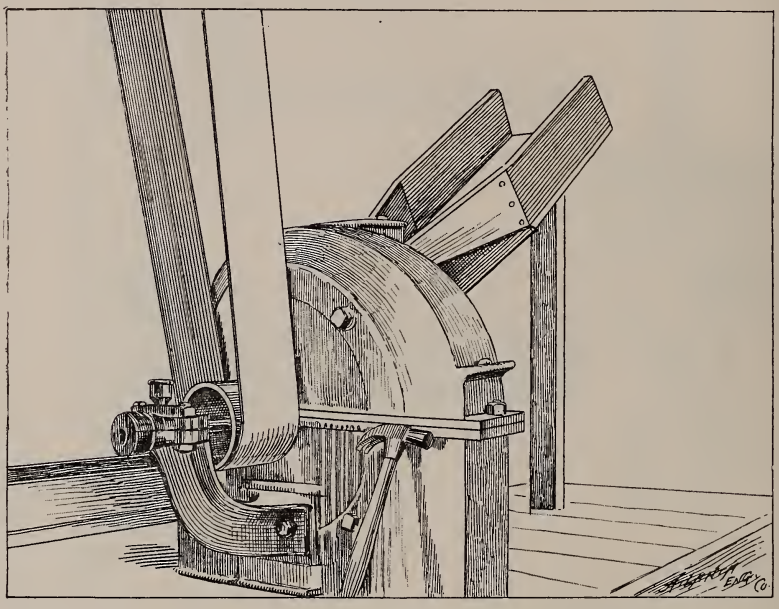


Corundum Washer Used at the Track Rock Mine, Union County, Georgia.

It is necessary, that all foreign substances be removed, since the material, to serve its purposes, must possess practically a uniform hardness. This is finally accomplished by further washing, in the series of crushings and siftings, which follow, in the reduction of the corundum to the various grades or "numbers." In this subsequent crushing, great care is exercised, to prevent the production of flour, since this is of much less value than the coarser grades.

The larger portion of corundum thus prepared is used in the manufacture of corundum wheels. In their manufacture, corundum is molded with some definite compound, of such a nature and so prepared, as to continually present a cutting surface.

FIG. 8.



CORUNDUM CLEANER USED AT THE TRACK ROCK MINE, UNION COUNTY, GEORGIA.

STATISTICS.[1]

The product of corundum and emery in the United States is from Rabun County, Georgia, Macon and Jackson Counties, North Carolina, Westchester County, New York, Chester County, Pennsylvania, and Hampden County, Massachusetts.

[1] Mineral Resources of the United States, 1893.

The following table shows the annual product of corundum and emery, since 1881:—

Annual Product of Corundum and Emery since 1881.

Years.	Quantity.	Value.	Years.	Quantity.	Value.
	Short tons.			*Short tons.*	
1881	500	$80,000	1888	589	$ 91,620
1882	500	80,000	1889	2,245	105,567
1883	550	100,000	1890	1,970	89,395
1884	600	108,000	1891	2,247	90,230
1885	600	108,000	1892	1,771	181,300
1886	645	116,190	1893	1,713	142,325
1887	600	108,000			

Emery Imported into the United States from 1867 *to* 1893, *Inclusive.*

Years ended—	Grains.		Ore or rock.		Pulverized or ground.		Other manufactures.	Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.		
	Pounds.		*Tons.*		*Pounds.*			
June 30, 1867	.....	.....	428	$ 14,373	924,431	$ 38,131	.....	$ 52,504
1868	.....	.....	85	4,531	834,286	33,549	.....	38,080
1869	.....	.....	964	35,205	924,161	42,711	.....	77,916
1870	.....	.....	742	25,335	644,080	29,531	.....	54.866
1871	.....	.....	615	15,870	613,624	28,941	.....	44,811
1872	.....	.....	1,641	41,321	804,977	36,103	.....	77,424
1873	610,117	$ 29,706	755	26,065	343,828	15,041	$ 107	70,919
1874	331,580	16,216	1,281	43,886	69,890	2,167	97	62,366
1875	487,725	23,345	961	31,972	85,853	2,990	20	58,327
1876	385,246	18,999	1,395	40,027	77,382	2,533	94	61,653
1877	343,697	16,615	852	21,964	96,351	3,603	.....	42,182
1878	334 291	16,359	1,475	38,454	65,068	1,754	34	56,601
1879	496,633	24,456	2,478	58,065	133,556	4,985	.....	87,506
1880	411,340	20,066	3,400	76 481	223,855	9,202	145	105,894
1881	454,790	22,101	2,884	67,781	177,174	7,497	53	97,432
1882	520,214	25,314	2,765	69,432	117,008	3,708	241	98,695
1883	474,105	22,767	2,447	59,282	93,010	3.172	269	85,49C
1884	143,267	5,802	4,145	121,719	513,161	21,181	188	148,890
1885	228,329	9,886	2,445	55,368	194.314	8,789	757	74,800
Dec. 31, 1886	161,297	6,910	3,782	88,925	365,947	24,952	851	121,638
1887	367,239	14,290	2,078	45,033	a 144,380	6,796	2,090	68,209
1888	430,397	16,216	5,175	93,287	.....	.....	8,743	118,246
1889	503,347	18,937	5,234	88,727	.....	.....	111,302	218,966
1890	534,968	20,382	3,867	97,939	.....	.....	5,046	123,367
1891	90,658	3,729	2,530	67,573	.....	.....	.....	71,302
1892	566,448	22,586	5,280	95,625	.....	.....	2,412	120.623
1893	516,953	20,073	5,066	103,875	.....	.....	3,819	127,767

a To June 30, only; since classed with grains.

HINTS TO PROSPECTORS.

"Show me corundum," an old corundum prospector says, "and I will show you corundum." The suggestiveness of this remark is at once apparent to any person, who has made a search for corundum. In other words, prospectors for corundum should be familiar with its associates. The knowledge, that chalcedony is an accompaniment of corundum, had aided the prospector, just quoted, in finding some of the prettiest prospects in Georgia.

Professor Jackson,[1] in 1864, finding margarite at an iron mine in Chester, Mass., predicted the occurrence of emery, which was discovered shortly after. At Rabun Gap, the writer discovered a corundum vein, by the presence of a thin seam of compact, scaly chlorite; in Habersham, his attention was attracted to a small aggregate of black hornblende and feldspar; other specimens of the same were soon found containing corundum. At Gainesville, he located the corundum, found in the stream, by margarite-mantled bowlders on the neighboring hill; and, from the presence of margarite, he discovered corundum east of Carrollton, in Carroll county.

Being assured of the presence of corundum by the associate minerals, and failing to find any specimens on the surface by simple inspection, proceed in the same manner as for gold, that is, pan the gravel. Good testing in this way should give favorable results; otherwise, there is little ground, on which to base hopes for a deposit worthy of further investigation. If corundum is disclosed, the next thing in order is to locate the vein or veins.

To accomplish this, it will be necessary, first, to determine the boundaries of the chrysolite formation; in other words, its contact with the inclosing formations. In some instances, the contact with these bodies will be apparent; in others, where the formation is obscured in ways previously noted, this may be accomplished, either by running a furrow, or, if necessary, a ditch, across the uncertain portions, *at right angles to the trend or strike of the formation.*

[1] Letter to Dr. J. L. Smith from Professor C. T. Jackson; Scientific Researches; J. Lawrence Smith, p. 43.

Finally, the contacts determined, confine work closely to those points near hornblende-gneiss, and keep a sharp watch for alteration and associate minerals of corundum. This caution is especially required, where the rocks are badly disintegrated.

The occurrence of corundum in the contact bodies has been observed by certain workers in North Carolina; hence, it will be advisable to also scan these critically.

CHAPTER VII.

AMERICAN LITERATURE ON CORUNDUM.

Very little has been published about corundum, either as to its mode of occurrence, or as to its origin ; and scarcely anything, except the most general statements, can be found in regard to the deposits in Georgia. The American literature on corundum is as follows: —

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Am. Jour. Sci., 2nd Series, Vol. XIII, 1852, *p.* 116.

Cooke, J. P.—" Corundum Regions of North Carolina and Georgia."
Am. Jour. Sci., 3rd Series, Vol. IX, 1874, *pp.* 48–49.

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System of Mineralogy of Jas. D. Dana; sixth edition; 1892, *pp.* 210–213.

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Proc. Boston Soc. Nat. Hist., Vol. XXII, Dec., 1882.

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Paret, T. D.—" Emery and Other Abrasives."
Jour. Frank. Inst., Vol. CXXXVII, 1894, *pp.* 353-372 *and* 421–438.

Parker, E. W.—" Emery and Corundum."
Mineral Resources of the United States, 1893.

Raborg, W. A.—" Corundum."
Mineral Resources of the United States, 1886.

Raymond, R. W.—" The Jencks Corundum Mine, Macon County, North Carolina."
Trans. Am. Inst. Min. Eng., Vol. VII, 1878, *pp.* 83–90.

Seal, T. S.—" Corundum in Chester County, Pa."
Am. Jour. Sci., 2nd Series, Vol. XI, pp. 267 *et seq.*

Shepard, C. U.—" On the Corundum Region of North Carolina and Georgia."
Am. Jour. Sci., 3rd Series, Vol. IV, 1872, *pp.* 109–175.

Silliman, B.—" Corundum etc., at Unionville, Pa."
Am. Jour. Sci., 2nd Series, Vol. VIII, p. 384.
Smith, C. D.—" Corundum and Its Associate Rocks."
" Geology of Western North Carolina."
Geol. Sur., N. C., Vol. I, Appendix D, 1875.
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Comptes Rendus, Vol. 31.
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CHAPTER VIII.

SUPPLEMENTARY.

NATURAL AND ARTIFICIAL ABRASIVES.

NATURAL ABRASIVES.

PUMICE.

Pumice is a spongy, vesicular variety of feldspathic lava, which owes its froth-like appearance to the tumultuous escape of gasses and steam, while it is yet in a viscous state. The bulk of pumice, used in this country, comes from Italy. Large deposits of it, found in California, are used to supply the demand on the Pacific coast. Quotations in New York for wholesale lots are:—

Select lumps @.....	$ .03½–	$ .15	per pound.
Original cakes @.....	.01½–	.02	" "
Powdered, pure, @.....	.01½–	.01¾	" "

Pumice is used principally for marble polishing.

INFUSORIAL EARTH.

Infusorial earth is composed of the extremely minute siliceous diatoms, the lowest order of unicelled plants. They form beds

upwards of thirty feet in thickness; and, according to Ehrenberg, a cubic inch of the material contains 40,000,000,000 shells. On account of its soft, chalky consistency, it is adapted particularly for fine polishing. Formerly infusorial earth was used chiefly as an absorbent of nitro-glycerine, in the manufacture of dynamite and other nitro-glycerine explosives, 25 per cent. of the product being infusorial earth. Now, in addition to abrasive purposes, it is used in the manufacture of soap; and it is coming into use in the manufacture of enamel brick, terra-cotta, fancy tiles and glazed-ware goods.

In the United States, it is mined chiefly in Maryland, Connecticut, Nevada, New Hampshire and New Jersey.

The following table shows the annual production of infusorial earth since 1880: —

Production of Infusorial Earth from 1880 *to* 1893.

Years.	Short tons.	Value.	Years.	Short tons.	Value.
1880	1,833	$45,660	1887	3,000	$15,000
1881	1,900	10.000	1888	1,500	7,500
1882	1,000	8,000	1889	3,466	23,372
1883	1,000	5,000	1890	2,532	50,240
1884	1,000	5,000	1891		21,988
1885	1,000	5,000	1892		43,655
1886	1,200	6,000	1893		22,582

TRIPOLI.

" Tripoli " is a term applied to a siliceous earth, which is mined extensively in Newton county, Missouri. It was first thought to be a species of decomposed quartz; but it is now considered a disintegrated siliceous limestone, from which the carbonate of lime has been leached out. The formation in Newton county is from ten to twenty feet thick, and covers over eighty acres, being the largest known deposit in the world.

On account of its porosity and absorptive qualities, the product is manufactured into water-filters and ink-blotters, which serve their respective purposes admirably. On account of its lack of iron, coarse sand or grit, it makes an exceedingly fine abrasive, when powdered, possessing a sharp cutting grain, that will polish

silver etc., without scratching. It is also used in the manufacture of soap and other cleansing preparations.

Henderson writes:—[1] "A tripoli or rotten stone, of excellent quality as a polishing material, is abundant near Dalton, and is found also in many other localities in this part of the State." Such properties should be investigated.

"The output from the mine" (at Carthage, Missouri,) "in 1892 was nearly 2,000,000 pounds, or 1,000 short tons of powdered material, and between 15,000 and 20,000 finished pieces of filter goods, the total value of which is estimated at about $30,000." [2] Work was continued on the property in 1893, and the output increased over that of 1892 about 25 per cent." [3]

BUHRSTONE.

A "buhrstone" is a cellular rock, very siliceous and exceedingly compact. The Tertiary deposits of the French basin have always afforded the best buhrstones, although American stones have served as well, for the coarser cereals.

In Henderson's report, [4] we find that the buhrstone, found in many portions of Southern Georgia, "has been pronounced by experts, as, in all particulars, equal to the best quality of French buhr. Also, that it exists in large quantities along and near the Savannah river, and at other points convenient to transportation. The stone varies from a light-gray to a reddish-brown color."

The buhrstone of Georgia occurs in the "Buhrstone Division" of the Middle Miocene series.[5]

This division extends from the Chattahoochee river at Early county, northeast to Burke and Screven counties, and on into South Carolina. According to Dr. Spencer, the extent of the buhrstone is limited in the mass, and is not confined to a single horizon.

The "roller process" in large mills has caused a decline in the

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[1] Commonwealth of Georgia, Part I, 1885, p. 139.

[2] Mineral Resources of the United States, 1892, p. 753.

[3] Mineral Resources of the United States, 1893, p. 679.

[4] The Commonwealth of Georgia, Part I, 1885, p. 138.

[5] First Report of Progress, Geol. Surv. Ga., 1890–91; J. W. Spencer; p. 149.

production of buhrstones, and this decrease will probably continue, on account of the introduction of emery-rock millstones.

The following table shows the value of buhrstones produced in the United States since 1880:—

Value of Buhrstones Produced in the United States since 1880.

Years.	Value.	Years.	Value.
1880	$200,000	1887	$100,000
1881	150,000	1888	81,000
1882	200,000	1889	35,155
1883	150,000	1890	23,720
1884	150,000	1891	16,587
1885	100,000	1892	23,417
1886	140,000	1893	16,639

The following table of imports shows, that the decline in the buhrstone industry has not been confined to stones of domestic production:—

Value of Buhrstones and Millstones Imported into the United States from 1868 *to* 1893.

Years Ended—	Rough.	Made into Millstone.	Total.	Years Ended—	Rough.	Made into Millstone.	Total.
June 30, 1868	$ 74,224	$	$ 74,224	June 30, 1881	$ 100,417	$ 3,495	$ 103,912
1869	57,942	2,419	60,361	1882	100,287	747	104,034
1870	58,601	2,297	60,898	1883	73,413	272	73,685
1871	35,406	3,698	39,104	1884	45,837	263	46,100
1872	69,062	5,967	75,029	1885	35,022	455	35,477
1873	60,463	8,115	68,578	Dec. 31, 1886	29,273	662	29,935
1874	36,540	43,170	79,710	1887	23,816	191	24,007
1875	48,068	66,991	115,059	1888	36,523	705	37,228
1876	37,759	46,328	84,087	1889	40,432	452	40,884
1877	60,857	23,068	83,925	1890	32,892	1,103	33,995
1878	87,679	1,928	89,607	1891	23,997	42	24,039
1879	101,484	5,088	106,572	1892	33,657	529	34,186
1880	120,441	4,637	125,072	1893	29,532	729	30,261

GRINDSTONES.

The Mineral Resources of the United States reports the main output of grindstones to be from Ohio and Michigan. The grindstones from Ohio are made from the sandstone of the geological formation known as Berea Grit. This underlies large areas in the northwestern part of Ohio, and takes on local names in different sections. Its color varies, in different localities, from white, brownish-white, grayish-white to yellowish-white; and its structure, from a fine and sharp grit to a coarse grit. The Michigan sandstone is blue, and possesses a fine, sharp grit. Both are used for sharpening edge tools.

The sandstones of Georgia have, up to the present, only local importance, although, for grindstone purposes, their fitness has been known for sometime. Henderson speaks of the itacolumite, or flexible sandstone, in certain localities, as affording "a suitable material, both for whetstones and grindstones, as do also some of the sandstones of Taylor's Ridge and of Chattooga and Lookout mountains." [1]

The annual production, since 1880, has been as follows: —

Value of Grindstones Produced in the United States, 1880 to 1893.

Years.	Value.	Years.	Value.
1880	$500,000	1887	$224,400
1881	500,000	1888	281,800
1882	700,000	1889	439,587
1883	600,000	1890	450,000
1884	570,000	1891	476,113
1885	500,000	1892	272,244
1886	250,000	1893	338,787

Grindstones Imported and Entered for Consumption in the United States, 1868 to 1893, Inclusive.

Years ended—	Finished.		Unfinished or rough.		Total. value.
	Quantity.	Value.	Quantity.	Value.	
	Long tons.		*Long tons.*		
June 30, 1868	.....	$ 25,640	.....	$ 35.215	$ 60,855
1869	.....	15,878	.....	99,715	115,593
1870	.....	29,161	.....	96,444	125,605
1871	385	43,781	3,957.15	60,935	104,716
1872	1,202	13,453	10,774.80	100,494	113,947
1873	1,437	17,033	8,376.84	94,900	111,933
1874	1,443	18,485	7,721.44	87,525	106,010
1875	1,373	17,642	7,656 17	90,172	107,814
1876	1,681	20,262	6,079.34	69,027	90,189
1877	1,245	18,546	4,979.75	58,575	77,121
1878	1 463	21,688	3,669.41	46,441	68,129
1879	1,603	24,904	4,584.16	52,343	77,247
1880	1,573	24,375	4,578.59	51,899	76,274
1881	2,064	30,288	5,044.71	56,840	87,128
1882	1,705	30,286	5,945.61	66,939	97,225
1883	1,755	28,055	6,945.63	77,797	105,852
1884	.....	.....	.....	.....	*a*86,286
1885	.....	.....	.....	.....	50,579
Dec. 31, 1886	.....	.....	.....	.....	39,149
1887	.....	.....	.....	.....	50,312
1888	.....	.....	.....	.....	51,755
1889	.....	.....	.....	.....	57,720
1890	.....	.....	.....	.....	45,115
1891	.....	.....	.....	.....	21,028
1892	.....	.....	.....	.....	61,052
1893	.....	.....	.....	.....	59,569

a Since 1884 classed as finished or unfinished.

[1] The Commonwealth of Georgia, Part I, 1885, p. 139.

OILSTONES AND WHETSTONES.

"The most important whetstone grit, known in the State, is the novaculite of Lincoln county."[1] The most important stone found in the United States for oilstones and whetstones is "novaculite," which is mined principally in Arkansas. Its discovery in Arkansas, as a material fitted for abrasive purposes, was made sometime prior to 1818, and, since that time, its suitableness has become more and more apparent, as shown by foreign export. The term novaculite (*novacula*, a razor) is applied to a class of exceedingly hard, fine-grained, siliceous rocks, which are particularly adapted to whetstone purposes. The cutting power of novaculite is due, according to Griswold,[2] to the presence of innumerable small cavities—rhombic in shape, and resulting evidently from the leaching out of lime in the form of calcite—whose sharp edges, partially assisted by the frequent occurrence of large siliceous grains, with jagged outline, go to make up the abrasive face.

The Georgia occurrences of novaculite are found in McDuffie, Oglethorpe, Troup, Meriwether, Heard and Lincoln counties. In Lincoln county, it occurs as a low hill two miles from Lincoln Court-house, and projects nearly vertically from the ground, over an area of four or five acres. It has several colors. Where exposed, it is straw-colored; below the surface, it is greenish-white. This is the occurrence, of which Commissioner Henderson speaks, in such strong terms. It has been much used, locally; but it has never been quarried to any extent; whether on account of its inferiority, or for lack of investigation, is not known. Its presence, however, within the State is worthy of notice.

Included in the productions of the United States "are the two grades of novaculite from Arkansas, known as the Arkansas and the Wachita stone; the fine-grained sandstone of Orange County, Indiana, known as Hindostan or Orange county stone; a gray sandstone, known as Lake Superior stone, from Cortland County, New York; Chocolate stone from Lisbon, New Hampshire; and scythe-

[1] The Commonwealth of Georgia, Part I, 1885, p. 139.

[2] Annual Report, Arkansas Geol. Surv., 1890, Novaculites; by Griswold; p. 90.

stones made from Indian Pond and Lamoille sandstones, quarried in Grafton County, New Hampshire, and Orleans County, Vermont, and from Berea, Ohio, "grit."

Production of Whetstones etc., by the Pike Manufacturing Company in 1892 *and* 1893.

Kinds.	1892.		1893.	
	Output.	Value.	Output.	Value.
Wachita stone.....pounds..	400,000	$ 60,000	300,000	$ 45,000
Arkansas stone.....do.....	20,000	12,000	12,000	12,000
Labrador stone.....do.....	500	50	200	20
Hindostan stone.....do.....	300,000	15,000	250,000	13,000
Sandstone.....do.....	100,000	2,000	100,000	2,000
Chocolate stone.....do.....	20,000	2,000	20,000	2,000
Scythestones.....gross...	16,000	50,000	13,000	40,000
Total.....pounds...	856,500	141,050	682,000	114,020
gross...	16,000		13,000	

Estimated Exports of Whetstones etc., in 1892 *and* 1893.

Kinds.	1892.		1893.	
	Amount.	Value.	Amount.	Value.
Scythestones.....gross...	8,000	$ 20,000	8,000	$ 19,000
Wachita stone.....pounds...	150,000	20,000	180,000	21,000
Arkansas stone.....do.....	9,000	12,250	8,000	10,500
Hindostan stone.....do....	75,000	2,250	100,000	3,500
Sandstone.....	.....	.....	50,000	1,000
Total value.....	.....	54,500	.....	55,000

Estimated Imports of Whetstones etc., in 1892 *and* 1893.

Kinds.	1892.		1893.	
	Amount.	Value.	Amount.	Value.
Turkey stone.....pounds..	1,000	$ 200	1,000	$ 200
Scotch stones (all kinds).....do.....	8,000	800	4,000	400
Razor hones.....dozen...	1,000	2,000	1,000	1,500
English scythestones,.....gross...	50	300	25	150
Norway Ragg scythestones.....	.....	None.	.....	None.
German emery scythestones.....	50,000	1,000	30,000	500
Total value.....	.....	4,300	.....	2,750

ARTIFICIAL ABRASIVES.

CRUSHED STEEL.

A prominent corundum mine owner and manufacturer informs the Survey, that the most prominent usurper of the corundum industry is "crushed steel." On account of the cheapness of the product, and the variety of uses, to which it may be put, it is for the present replacing much corundum and emery in the arts.

A concise description of this is given in the Mineral Resources of the United States, 1892, as follows:—"Another recent invention in the line of abrasives, to which attention has been called, by an interesting exhibit at the Columbian Exposition, is "crushed steel," manufactured by the Pittsburg Crushed Steel Company, limited, of Pittsburg, Penn. This product is obtained from crucible steel, highly carbonized, and made crystalline in structure, by manipulation in furnaces and chemical bath treatment. It is then reduced to small crystals, by crushing under heavy machinery, after which it is assorted into sizes by a system of sieves. The larger sizes, which vary from about the size of a No. 2 bird shot to one-fortieth of an inch, are classed as crushed steel proper, and used for sawing stone, particularly those varieties possessing hard and gritty qualities, such as granite, sandstone, marble etc. Grains, which pass through sieves, ranging from forty to one hundred and fifty meshes to the inch, are classed as "steel emery," and are used upon rubbing beds, and for polishing purposes. The finest product is, by an oxidizing process, manufactured into putty-powder and rouge, for polishing marbles, granites, agate and glass.

"The crystals of crushed steel and steel emery present sharp, cutting edges, having about the same angles as quartz, when crushed. They are exceedingly hard, and are more effective, under the saw blades and on the rubbing bed, than sand. The effectiveness of crushed steel and steel emery is due to the fact, that the crystals do not wear away and become smooth. A grain of crushed steel, under the microscope, presents a series of crystals; and, if sufficient force be applied, they are detached; but they main-

tain their crystalline form and abrasive qualities. For this reason the material can be used a great number of times, and in order to effect the greatest economy in its use, the manufacturers of crushed steel have also invented automatic attachments for saw gangs and rubbing beds, by which the steel once used is saved and returned. The efficacy of these products—crushed steel, steel emery, and the putty-powder and rouge—has been attested by stone-workers and manufacturers of lenses."

CARBORUNDUM.

An artificial abrasive, which has been attracting unusual attention lately, is termed by its inventor, Mr. E. G. Acheson, of Monongehala City, Pa., "Carborundum." The object of the invention was to produce a substitute for corundum and other abrasive materials. Reports as to its success have been contradictory. As a substitute for corundum, it thus far fails, mainly (1) because the manufacturers are not yet able to produce it as cheaply, and (2) because it lacks the toughness, being extremely brittle.

The description of carborundum, its manufacture, properties and uses, as given by the Committee on "Science and the Arts," of the Franklin Institute,[1] is as follows:—

"The method of manufacture consists in general, in subjecting to an extremely high temperature, and for a considerable time, mixtures of carbon with silica, or siliceous materials, and a suitable flux.

"The inventor finds, that the heat, generated by an electric current, affords him the most efficient conditions, for securing the high temperatures, needed to bring about the reaction, and accordingly states his preference for the use of the electric furnace.

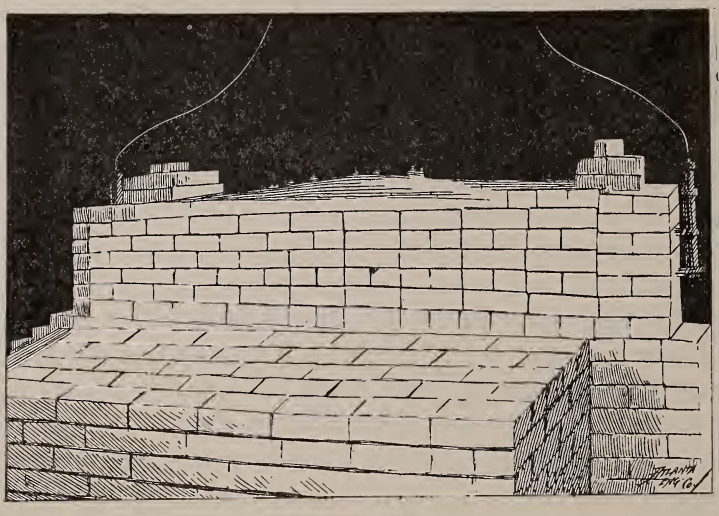
"The following general description will serve to explain the mode of operation:—

"An intimate mixture of carbon and sand is introduced into a rectangular box of brick or fire-clay, constituting the furnace chamber, the mixture being so placed, as to surround a core of granular carbon. Into each end of the chamber project several

[1] Journal of the Franklin Institute, Vol. CXXXVII, 1894, pp. 402–407.

rods of the carbon, making connection with the core, and, through these rods and the core, is passed a current, sufficient in quantity, and for a sufficient length of time, to fuse the contained silica, and bring about its subsequent combination with a portion of the carbon, to form a new substance, a silicide of carbon, to which the name of carborundum has been given.

Fig. 9.



Electrical Furnace for the Manufacture of Carborundum.

"Upon removal from the furnace, the carborundum is found as a porous cinder-like mass, formed of groups of small, glittering crystals of yellowish-green, bluish-green, or blue color, surrounded by more or less coherent masses of partly altered carbon.

"The separation of the carborundum from the other constituents of the mass is first effected, as completely as may be, by hand. The selected material is washed in water, then treated with acid, to remove soluble impurities (iron, alumina, lime etc.), again washed, then dried and crushed. By this means the individual crystals are separated, and the purefied material is then separated into commercial sizes of different degrees of fineness, by a process of float-

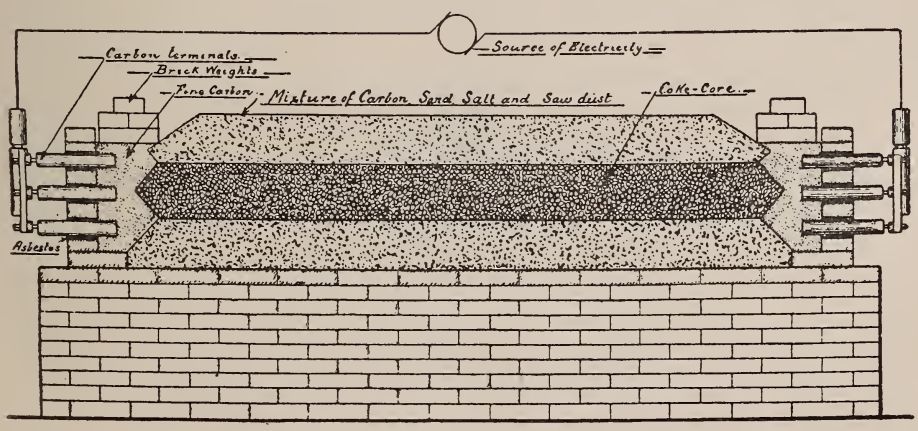
ation in a current of water, the several grades being thus automatically collected in separate receptacles.

"An analysis of the product thus formed shows, that it is a compound thus far new in chemistry, a combination of one atom of silicon with one atom of carbon, or, in chemical terms, a silicide of carbon, having the formula SiC. The re-action involved consists in the withdrawal, by the carbon, of two atoms of oxygen from the silica of the sand or clay, and the combination of the nascent silicon with a portion of the surplus highly heated carbon, according to the equation,

$$SiO_2 + 3C = SiC + 2CO.$$

"It is well known to chemists, that the formation of silicide of carbon, by the direct reduction of silica with carbon, has hitherto been impossible, at any temperature attainable in the laboratory. By the employment of the heating effect of the electric arc, in a furnace of the simple construction described above, in which the

FIG. 10.



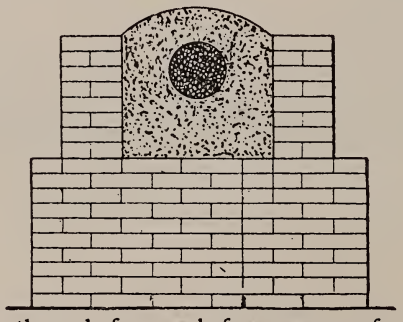
Longitudinal section through furnace before passage of current.

heat can be confined, the temperatures obtainable are so much greater, than can be realized by any other known methods, that re-actions heretofore deemed impossible are readily effected. In

the hands of Moissan and others, the electric furnace has lately been made to yield results of a nature, as extraordinary and unlooked-for, as those, which followed upon the first application by Davy of the voltaic battery, to effect chemical decompositions. In employing the electric furnace method, therefore, to bring about the desired results, Mr. Acheson deserves the credit of having applied the only method, by which it could have been successfully accomplished.

"At this point, it is worthy of notice that Moissan, whose recent experimental work with the electric furnace has greatly extended our knowledge of chemical re-actions, taking place at enormously high temperatures, produced this same compound (SiC), and described its properties, in a communication presented to the French Academy at the session of October, 1893; also, that Schutzenberger formed it, by the combined reducing action of *carbon and silicon* on silica. Mr. Acheson's results were obtained and duly announced, however, before the publication, by these investigators, of their results.

Fig 11.

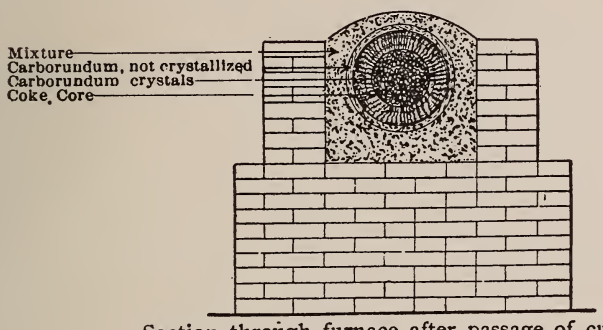


Section through furnace before passage of current.

"The interest attaching to this compound, because of its novelty and the mode of its production, is greatly increased by the remarkable properties, which it exhibits. Those properties, which are more particularly referred to, are the following: —

"*Permanence.*—Being formed at an enormously high temperature, it is natural to anticipate, that it would be stable, at all temperatures below that of its formation; but, in addition to this stability,

FIG. 12.



Section through furnace after passage of current.

it appears to be capable of resisting many of the most powerful chemical reagents. The only reagents, that appear to be capable of decomposing it readily, are the caustic and carbonated alkalies, in the state of fusion.

"*Infusibility.*—The substance appears to rank with the most infusible substance known, yielding only to the heat of the electric furnace.

"*Hardness.*—In this quality, the substance approaches, if, indeed, it does not equal the diamond, the hardest of known substances. This quality is one, which, at first, would not be readily recognized, being masked by the brittleness of the crystals.

" It is upon its hardness, that the present and prospective applications of the material are based. It is, in brief, as an abrasive material, for grinding and polishing metals, glass and precious stones, that carborundum has been found to possess decided merits; and, when its unique physical characteristics are so thoroughly understood, that they may be utilized to the best advantage, the material, in all probability, will rank among the most valuable abrasives known to the arts. It was first usefully applied, for the cutting and polishing of diamonds and other precious stones, and,

from reliable evidence presented in the course of this investigation, its cutting qualities will bear comparison with those of diamond-dust. It is reported to be specially useful for polishing such gems, and one of the members of the sub-committee charged with this investigation, having tested the merits of the material on various gems, reports very favorably upon it.

" It is used in considerable quantity, in the grinding of the glass stoppers and bulbs of the new Westinghouse electric incandescent lamps, for which service it answers very satisfactorily. It is found very efficient in certain finishing operations in machine work, as, for example, for brass valve grinding. Of late, it has been introduced in the form of small wheels, discs and points, for use in dentistry, in place of the corundum tools in general use ; and, finally, it has just been introduced in the market in the form of wheels of large size, for general grinding and cutting purposes in machine work, as a substitute for emery wheels.

" The sub-committee charged with this investigation was supplied with a considerable number of samples of the material, in powder form and made up into wheels, with which to make trial of its usefulness. The results are given in what follows : —

" A number of wheels, of the sizes and grades indicated as most suitable for certain special uses, were sent to a number of machine shops, whose proprietors had expressed their willingness to test them. (Their reports form part of the record of this case, and are accessible for reference.)

" The results of the tests of these large wheels were very contradictory, the wheels being pronounced very satisfactory by some, and being condemned by others; but, in the main, the verdict was unfavorable. The absence of concordance in these results would seem to indicate the existence of faulty methods of manufacture, possibly the use of unsuitable binding material. It is certainly not unreasonable to assume, that, when more experience has been gained with carborundum, and its peculiar physical qualities are better understood, more uniform and better results, may confidently be looked for.

The smaller wheels and points, made for dentists' use, were found to cut porcelain much faster than wheels of corundum and shellac of the corresponding sizes and grit, and to wear away more slowly than the latter. When used dry, they cut faster than dry corundum wheels, and do not glaze so readily as these. This quality makes their use cleanly for the operator.

The results of these practical trials may fairly be summarized in the statements, that the new material possesses remarkable properties as an abrasive, being the first artificial substance, thus far produced, which compares favorably with bort in hardness, and which is capable of being used as a substitute for it; that, when its peculiarities are better understood, it should be capable of yielding cutting wheels of high efficiency, to take the place of abrasives in common use; and that it should find general application in the arts, wherever its price is not prohibitory."

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